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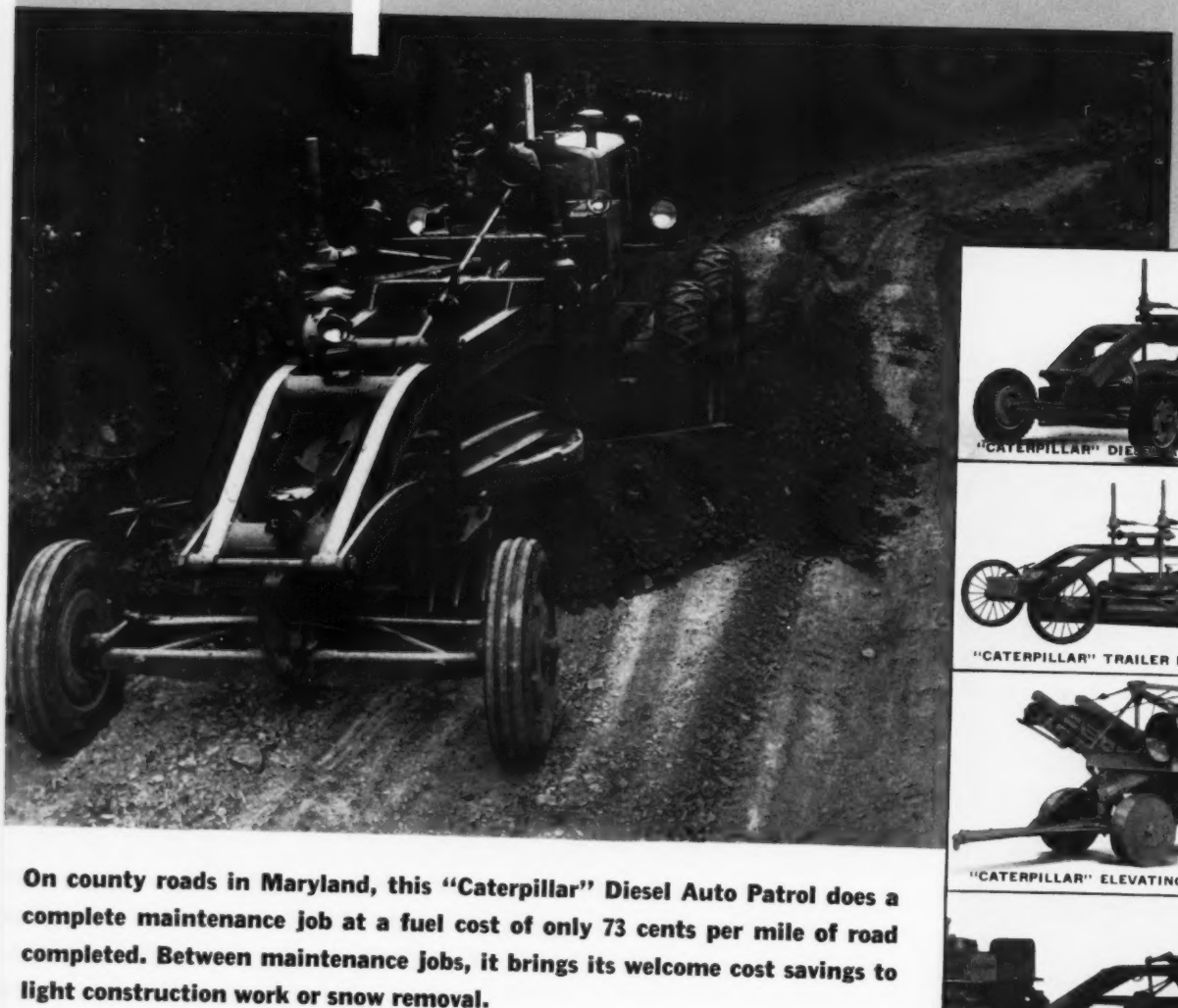

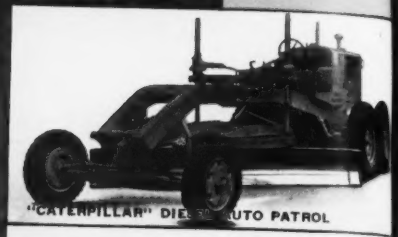

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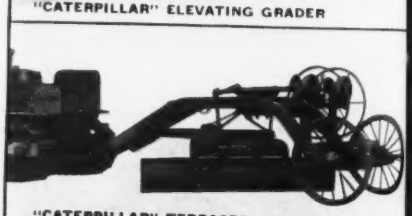

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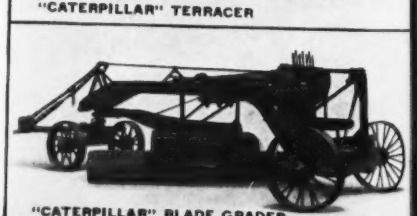

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A MOMENT WITH THE PUBLISHERS

No Second Shots

SPEAKING recently at a convention of Structural Clay Products, Inc., Charles Wheeler Nichol, Chicago architect, made a point concerning construction practice that often is overlooked in appraising the skill and responsibility of those who follow it.

He reminded his hearers that most mechanical products are produced only after repeated service tests, during which each material or part, singly or in combination, is given a chance to show just how it will behave in practice. After such preliminaries, a completed unit such as a motor car, is tested in performance. After exacting tests under every conceivable service condition, the product is revamped in whole or in part, new parts are designed to supplant those that failed and new materials or processing may be devised to overcome disclosed defects. After many such successive tests under all sorts of conditions, a finished and tested product eventually is available to the prospective user.

BUT those who build enjoy no comparable opportunity to test their achievement, to correct their errors, to revamp their designs or to take a fresh start at their problem. They must be right the first time. They must estimate their loads, floods or traffic, not only as of today but even for the years to come. They must appraise, once and for all, *all* the forces that may affect the adequacy or security of their work.

On the basis of those appraisals and their best judgment, they must prepare their designs to meet conditions many of which simply cannot be determined accurately. In all this they must be right the first time; it will be their only time.

Then, from the plants of scores of producers, many of them hundreds of miles from the job, they must assemble on the ground their materials and parts; into the earth they must probe only to disclose new uncertainties; through every vicissitude of weather they must conduct the vital processes of fabrication by which each part may come to bear its allotted share of the task of the whole. The constructor must assemble and supervise, under the exacting conditions of the field, the workers of many crafts and must take responsibility for the work of each. Each producer of materials or parts must ship his wares from his distant plant with reasonable certainty that they will fit precisely into the needs of the whole.

All must score a bull's-eye on their first shot; they will have no second chance.

If the building be defective as to access or service facilities, if the bridge be inadequate as to channel clearance or deck width, if the dam be insecure as to foundations or abutments, there is no chance to subject it to a service test and to return it to the shop for revision. Construction tolerates no second thoughts. Once the builder has fixed the capital entrusted to him, there, for better or worse, it must remain fixed. And if his work should fail, structurally or economically, he has no out but to scrap it and to chalk up against his reputation the loss that may have been incurred.

SOMETIMES practitioners in other branches of the profession are inclined to make much of the refinement and perfection of their works as contrasted with those of the civil engineer and architect. That all may be. But in appraising the skill of the constructor it is worth remembering that the builder of a Holland Tunnel, a San Francisco Bay Bridge or a Portsmouth flood wall *must be right the first time.*

He has no proving ground or testing floor to serve as a private graveyard for his defective judgment or technical deficiency. He gets but one chance and if he fail, his blunder may be read by all who have eyes to see in terms of sacrificed lives or dissipated treasure.

It is at once an inspiration and a challenge that Mr. Nichol offers to his brother builders.

Willard Chevalier

ENGINEERING NEWS-RECORD Published every Thursday. Vol. 117, No. 22. Price 25c per copy. Subscription, domestic, Canada, Mexico, Central and South American countries, $5 per year. All other countries, $9 a year or 36 shillings. Entered as second-class matter October 29, 1936 at the Post Office at Albany, N. Y., under the act of March 3, 1879. Printed in U. S. A. Cable address "McGrawhill New York." Member A.B.P. Member A.B.C.

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Editorial and Executive Offices: 330 West 42d St., New York. Publication Office: 99-129 N. Broadway, Albany, N. Y. Branch Offices: 520 N. Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, London, W.C., 2, England; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga.

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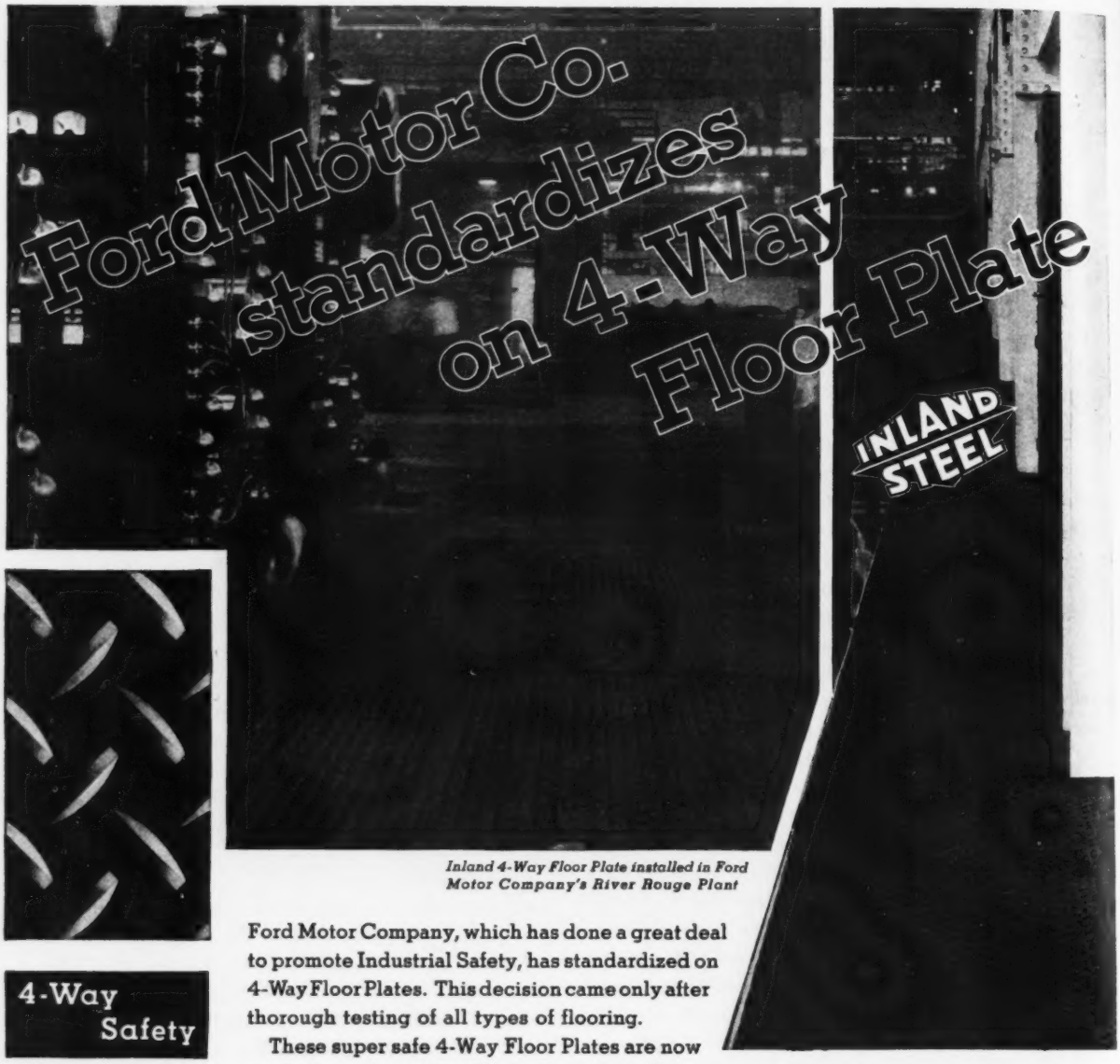

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The projections overlap uniformly, providing extra strength and stiffness—4-Ways.

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November 26, 1936

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■

What of the TVA?—Much has been said for and against the Tennessee Valley Authority since it was set up in 1933. Some of its specific accomplishments, such as the building of the Norris Dam, are well known, but what of its accomplishments as a whole? Do they show that unified development of a river basin is practical? To help its readers answer this question, *Engineering New-Record* begins the publication of a series of articles on the TVA in the Dec. 3 issue.

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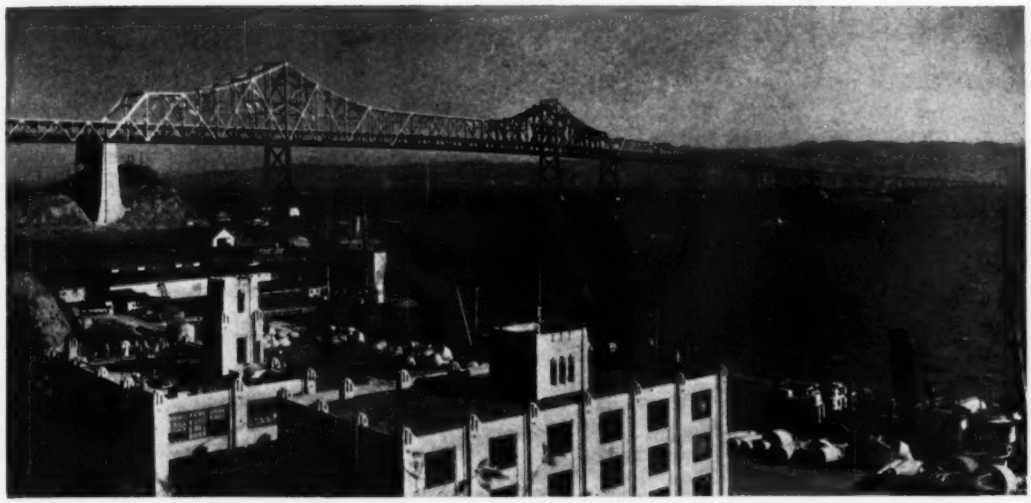


FIG. 1—THE 1,400-FT. CANTILEVER of the East Bay crossing. Beyond are the 504-ft. spans and the 288-ft. spans.

East Bay Crossing of the Bay Bridge

Steel structure includes longest and heaviest cantilever in the United States which is supported on tall towers and anchored at only one end—Erection by two-derrick travelers

By C. H. Purcell, Chas. E. Andrew and Glenn B. Woodruff

Chief Engineer, Bridge Engineer and Engineer of Design, Respectively, San Francisco-Oakland Bay Bridge

THE EAST BAY CROSSING of the San Francisco-Oakland Bay Bridge, spanning the waterway between Yerba Buena Island and Oakland is in every respect a different type of structure from that between San Francisco and the Island. Containing 60,500 tons of structural steel and having, as one of its parts, the longest and heaviest cantilever span in the United States, the East Bay Crossing would of itself rank among the major bridges of the world. Despite the fact that it is overshadowed by the more spectacular West Bay suspension spans, the cantilever presented the greater difficulties in design, fabrication and erection.

The span layout of the East Bay Crossing (for diagram see *EN-R*, Mar. 22, 1934, p. 375) consists of four 288-ft. spans crossing a valley on the island, the 1400-ft. cantilever span with its two anchor arms of 508 ft., five spans 504 ft. c. to c. of pins, a 50-ft. braced tower, 14 spans 288 ft. c. to c. of pins and a steel and concrete viaduct 1072 ft. long. Among the determinants of this layout were the following:

(1) The main navigation channel is at the edge of the Island. The East Bay pierhead line is only 2900 ft. from the Island. The 1400-ft. span with a vertical clearance of 185 ft. above mean higher high water and three additional spans of 500 ft. with a clearance of 165 ft. at the pierhead line were requirements of the War Department permit.

(2) East of the pierhead line the water is comparatively shallow and the problem for this part of the crossing was that of so balancing costs of superstructure and substructure as to secure the greatest economy.

(3) Foundation conditions (*EN-R*, Aug. 23, 1934, p. 227) were such that deep foundations were required; the one at the east end of the 1400-ft. span reached a record depth of 242 ft. These conditions were also such as to make it essential to keep the foundation loads to a minimum. For this reason steel towers rather than the usual masonry shafts were used to support the superstructure, except where the height of the masonry shaft would be less than 60 ft.

A masonry pier of the height required to support the cantilever and the other high level spans would have afforded little resistance to wind and earthquake forces in a longitudinal direction. The steel towers have even less longitudinal rigidity. To secure the required longitudinal stability the west end of the cantilever was anchored by a heavy masonry pier founded on the rocky tip of the Island. At the east end of the 504-ft. spans a 50-ft. braced tower was erected, on a pier 100 ft. wide, to furnish another point of longitudinal anchorage. The expansion for the distance of 5000 ft. between these two points is taken by a split column at the east end of the cantilever. This expansion involves a possible movement of 20 in. each way from normal. Similar provisions for anchorage and expansion were made at other points of the structure.

(4) Two horizontal curves were required in the structure, one on the Island truss spans to connect to the tangent of the West Bay Crossing, the other at the east of the 504 ft. spans

FIG. 2—TRAVELER erecting 288-FT. SPAN. Temporary bent on steel piles in foreground. Pile puller in span behind traveler is removing falsework piles.

which was introduced to avoid interference with the Key System ferry terminal.

(5) The usual procedure of selecting span lengths and then determining economical truss depths was to some extent reversed by the condition of the double-deck cross section. To provide satisfactory clearances over the upper-deck roadway and sufficient depth of portal and sway bracing, a truss depth of about 80 ft. was required. Where the top chord was braced by the upper-deck roadway, the truss depth became about 38 ft. For economical proportions these truss depths corresponded to the adopted span lengths of 504 ft. and 288 ft.

Design

With these span lengths and having adopted specifications for loads and unit stresses (*ENR*, Mar. 22, 1934, p. 371), the design of the simple truss spans presented no unusual problems. Silicon steel was used in all members where it resulted in a saving of weight, except that heat-treated eyebars were used for the bottom chords of the 504-ft. spans. The principal reason for the use of these eyebars was that the designers had more confidence in the pin joints than in the heavy riveted splices that otherwise would have been required. The higher unit stresses and the smaller amount of detail material resulted in a saving in weight, an advantage that was offset to some extent by the fact that the eyebar chords rendered erection by cantilever methods impracticable.

For architectural reasons, tied arch and self-anchored suspension designs were investigated for the 1400-ft. span. Even on this basis, the results were not as satisfactory as the adopted design. Both in weight of steel and in cost of erection, these other designs were much more expensive. Various profiles of the cantilever were investigated. A curved top chord in the suspended span of the cantilever (and in the 504-ft. spans) would have reduced the weight of steel slightly, but not sufficiently to balance the increased costs of fabrication and erection.

The anchoring of the cantilever structure in a longitudinal direction at only one end had several advantages. It permitted a continuity of the diagonal web system throughout the structure. It avoided the necessity for elaborate expansion details in both the floor and the lateral system at the ends of the suspended span, as well as traction and earthquake brakes at the same points. It reduced the number of points at which jacking devices were necessary during erection. The arrangement also avoided necessity for expansion rollers which always are a source of trouble.

There were accompanying disadvantages. The arrangement results in stress dissymmetry. Since all longitudinal forces are taken at the one anchorage point, the chord stresses from longitudinal earthquake and wind at the west end of the anchor arm are double what they would be in the case of two points of anchorage. This required some additional section in these chords. Difficulties in stress analysis of the lateral system were introduced, since this system became continuous over four supports, fixed at the west end and on slightly yielding supports at the steel towers.

There have been several cases of long-span bridges where the live load carrying capacity was reduced by reason of underestimating the weight of the steelwork and the dead load stresses caused thereby. In this case every precaution was taken to make ample provision for the dead load of the structure. Although layouts of panel points were made in the design department and the weights of steelwork calculated therefrom, the fabrication of the 504-ft. spans and of the cantilever was delayed until weights could be calculated from approved shop detail plans and the stresses rechecked using these weights. As a provision for future utilities not contemplated at present, an excess dead load allowance of 500 lb. per lineal ft. of bridge was included in the calculation of the dead load stresses.

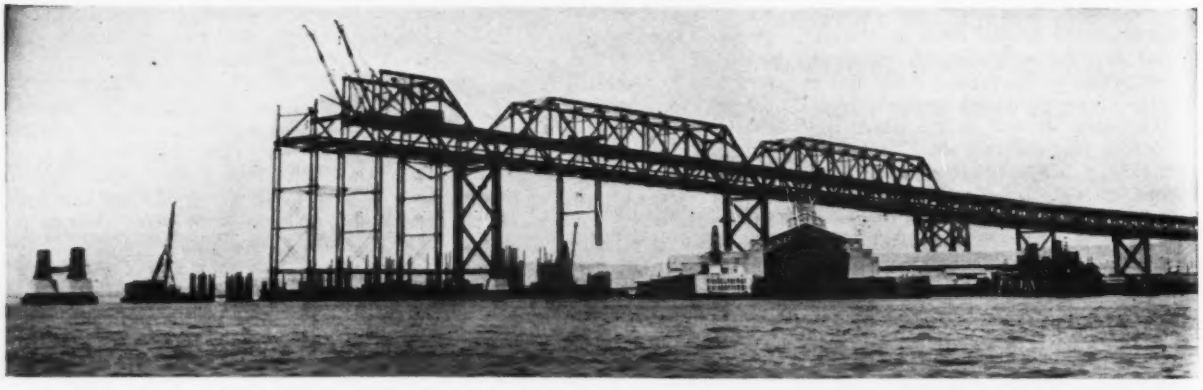
Earthquake stresses

The stresses in the superstructure were calculated for seismic forces equal to 10 per cent of gravity acting in any direction. The stresses set up by these horizontal forces, however, were not of sufficient magnitude to call for increase of section beyond that required by dead, live, temperature, and wind loads.

In a structure of this nature some deviations from usual methods of calculating earthquake stresses are necessary. Stresses in the lower chord of the cantilever due to an earthquake acting parallel to the bridge center line, vary from zero at the east end to a maximum at the west end. The stresses produce deformations in the chord so that the chord acts as a spring. By taking this action into consideration, the longitudinal earthquake stress in each lower chord at the west end is reduced from 3000 kips to 1600 kips.

While it is possible to derive theoretical rules for economic proportions of cantilevers, these rules are generally invalidated by the necessity of placing

FIG. 3—ERECTION of 504-FT. SPANS on steel falsework bents.



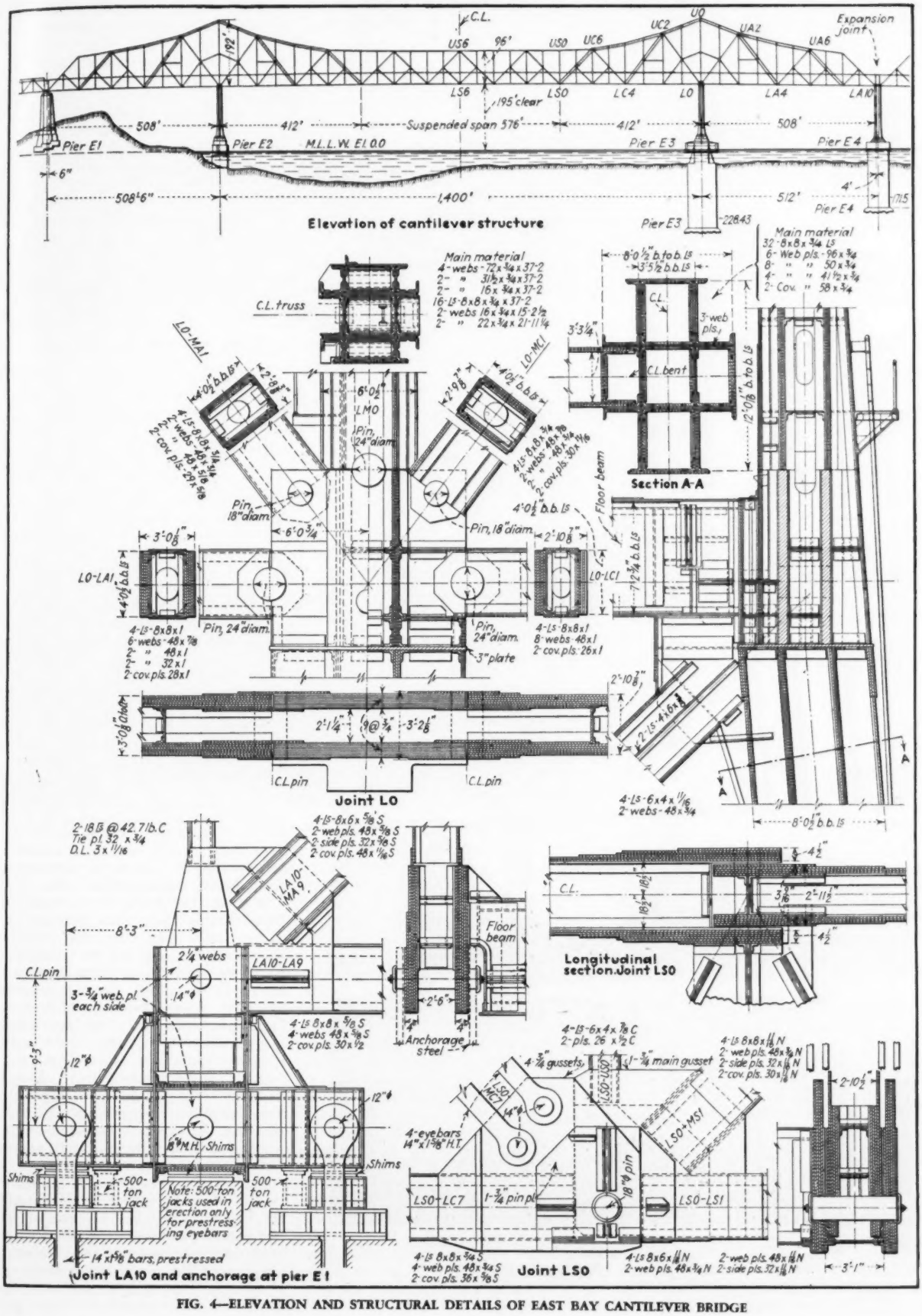


FIG. 4—ELEVATION AND STRUCTURAL DETAILS OF EAST BAY CANTILEVER BRIDGE

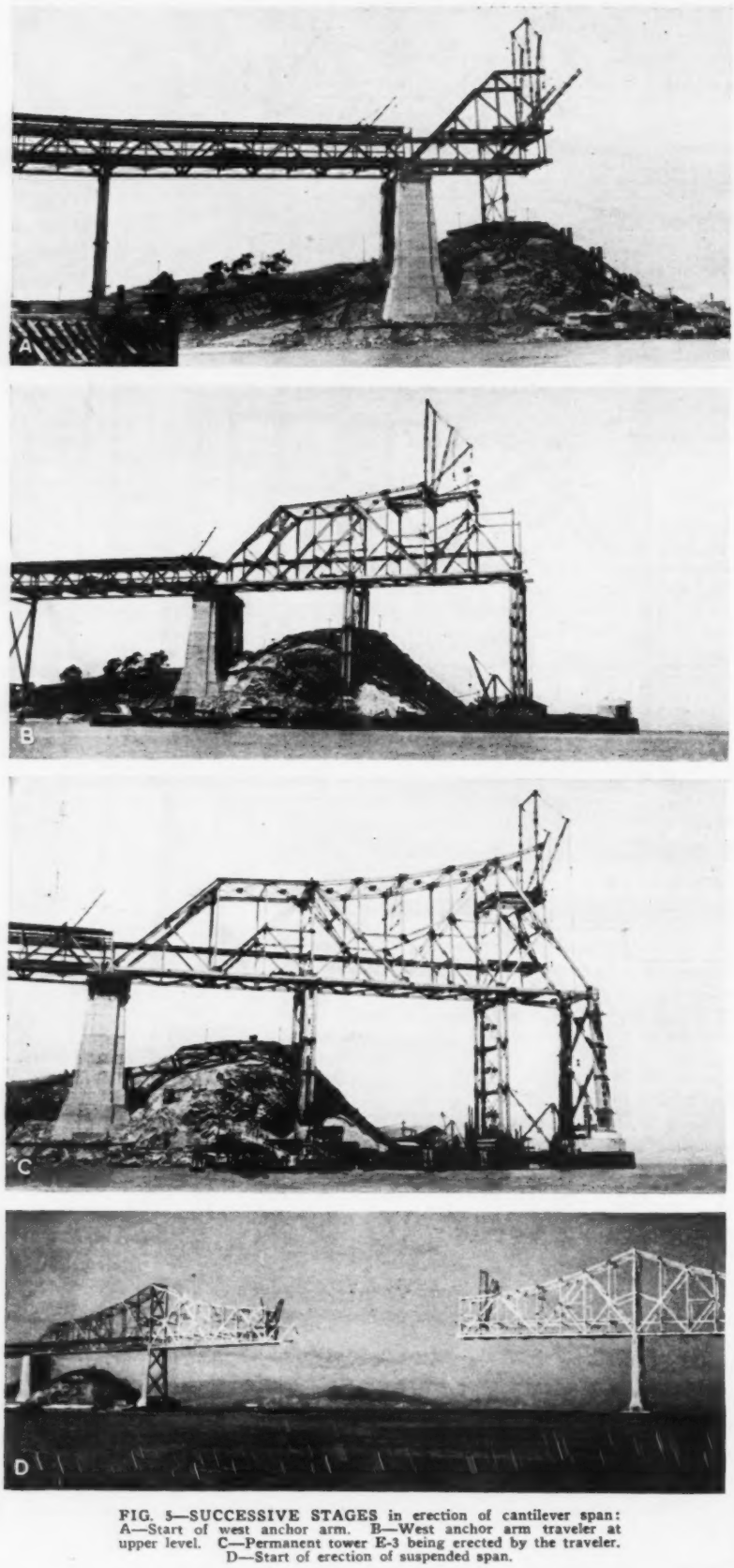


FIG. 5—SUCCESSIVE STAGES in erection of cantilever span: A—Start of west anchor arm. B—West anchor arm traveler at upper level. C—Permanent tower E-3 being erected by the traveler. D—Start of erection of suspended span.

additional metal to provide for erection stresses. These stresses in turn depend upon erection methods. The design was based on the assumption that the 1400-ft. span would be erected by the cantilever method using guy derricks, an assumption that fitted very closely the equipment later designed for the purpose. The proportions of the structure were made such that extra material to provide for erection stresses was required only in some of the web members, especially in the upper verticals which supported the traveler, in certain verticals and diagonals at the temporary erection bents and in the false top chords at the ends of the suspended span.

Large tonnage of nickel steel

Nickel steel was used in the main compression members and also, where rigid members were required, for erection, in the bottom chords of the suspended span. The use of some 3500 tons of this high strength material resulted in lighter members with a consequent reduction in dead load and earthquake stresses. Furthermore, with material of less strength, each member would have required either greater depth or greater thickness of material to secure the required area. The greater depth would have increased the secondary stresses; greater web thickness would have increased the grip of rivets beyond the maximum of $7\frac{1}{8}$ in. for $1\frac{1}{4}$-in. diameter rivets.

Heat-treated eyebars were used for main tension members, and silicon steel was used for secondary truss members and for most of the floor and lateral system. Carbon steel was used for details and minor members. Manganese rivets were used for the heavier joints, and pins were chrome-nickel steel, heat-treated. Quantities of the various structural steels in the cantilever structure, not including the supporting towers, are given in the accompanying table.

In developing details of the members, closed box sections with manhole entrances were used wherever possible. This saved the weight of the lacing that otherwise would have been necessary. Lacing is difficult to maintain and its structural action somewhat uncertain. Pins were used at all points where heavy secondary stresses would occur otherwise and also to avoid riveted connections of excessive length. Eyebar members were packed in two parallel rows one above the other in the plane of the truss. This reduced the width of the member, and the increased depth gave a more substantial appearance.

Secondary stresses were calculated for all members of the cantilever and the 504-ft. spans. On account of the long panels and moderate depth of members, these stresses are within reasonable limits. The trusses were cambered by making the length of members and angles of the connections such that

FIG. 6—PLACING LIGHT-WEIGHT CONCRETE on upper deck roadway. Hand vibrators were used in addition to mechanical vibrators mounted on the finishing machine in the background.

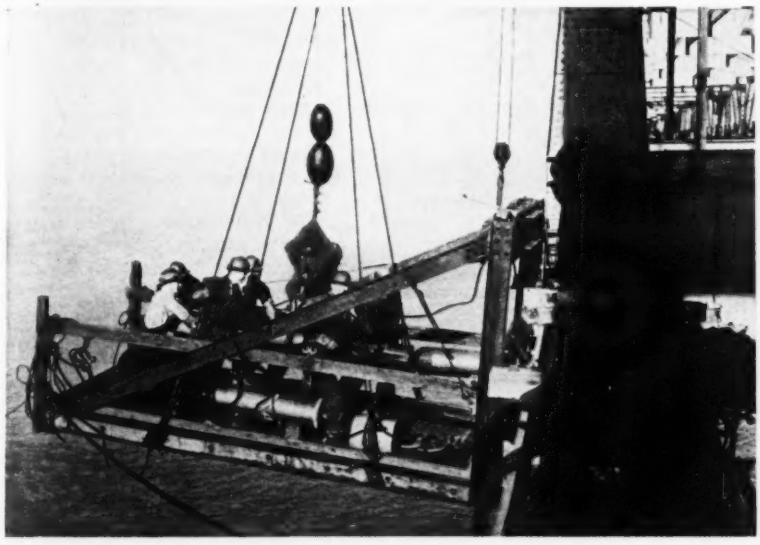


FIG. 7—DRIVING the closing pin in the suspended span of the East Bay Cantilever.

secondary stresses are theoretically zero under full dead and half live load. The end connections of the floorbeams were set at such a bevel as to relieve bending stresses in the verticals.

Before erection, strain gage points were established in a large number of members. Strain gage readings were taken during erection and in the completed structure. This data had not yet been reduced when this was written.

Fabrication

At all stages the shopwork was of a character to avoid damage to the material and to insure a good fit in the field. All rivet holes were subpunched or drilled, then reamed, and all sheared edges were planed. All compression chord joints were milled, and all rivet holes in chord joints were reamed while assembled and the joints for diagonals were reamed to steel templates. As a result of these precautions, there were practically no shop errors that required correction in the field.

Truss span erection

The 288-ft. spans were erected by a semi-cantilever method in which temporary upper chord ties and lower chord struts were placed over the piers. The falsework consisted of steel bents supported on steel H-piles. Since the eyebar bottom chord of the 504-ft. spans did not permit cantilevering, a steel falsework bent was placed under every main panel point. A horizontal wind truss at El. +25 was placed in this falsework system.

These spans were erected by a 194-ton traveler supported on twelve two-wheel trucks which ran on four 130-lb. rails placed at upper deck level. The frame of the traveler was 102 ft. long with a sill width of 60 ft. and a rear width of 44½ ft. The traveler carried two derricks, each with booms 87 ft. in length for the 288-ft. spans, subsequently lengthened to 100 ft. for the 504-ft. spans. These booms had 12-ft. trussed gaffs which carried the runner lines. The 44-ft. masts were spaced 42 ft. apart. The front stifflegs were in a plane at right angles to the bridge centerline and the rear stifflegs met at a common point at the rear of the derrick. This allowed the booms to swing to the rear while erecting the top bracing system of the 504-ft. spans. The derrick had a capacity of 20 tons at 100-ft. radius. The hoisting engines, which were mounted on the traveler, were triple-drum, three-speed, with a swinger attached and were operated by gasoline engines.

The erection of the Yerba Buena truss spans proceeded similarly to that of the east 288-ft. spans. The principal difficulty was that the rugged terrain made it difficult to get material to the traveler. The traveler used in erecting these spans had two 90-ft. booms at the front and one 50-ft. boom at the rear. Each of the front booms was rigged for a set of falls and a runner line. The rear boom was rigged for falls only. The derricks were operated by two 60-hp. tractor-hoist combinations located on the ground at the west end of these spans.

Guy derricks erect cantilever

Upon completion of the Yerba Buena spans this traveler erected a second traveler to be used for erection of the cantilever. This second traveler had two 50-ton guy derricks mounted on a mast beam. The masts were 118 ft. high and were spaced 44 ft. on centers; the booms were 100 ft. long and were rigged for main and auxiliary falls and a runner line. Power for operating the traveler was supplied by two 175-hp. gasoline engines and two auxiliary engines, all of which were placed on the bridge deck and did not move with the traveler. The traveler was supported and moved on skids made of the beams designed to be used later as railway stringers in the suspended span. In lower position, these skids were supported on the upper deck floorbeams which were in turn shored from the lower deck floorbeams. In its elevated position the skids were supported by floorbeams temporarily attached to the truss verticals.

The sequence of erection, which was the same for both halves of the cantilever is shown in the accompanying drawing. The traveler used in the

STEELS USED IN THE CANTILEVER STRUCTURE

	Tons	Per Cent	Cost Per Lb. Erected (cents)
Nickel	3,576	7	9.15
H. T. Eyebars and Pins	4,816	9	7.30
Silicon	25,312	48	6.75
Carbon	19,102	36	6.35
Manganese Rivets.	84	..	6.40

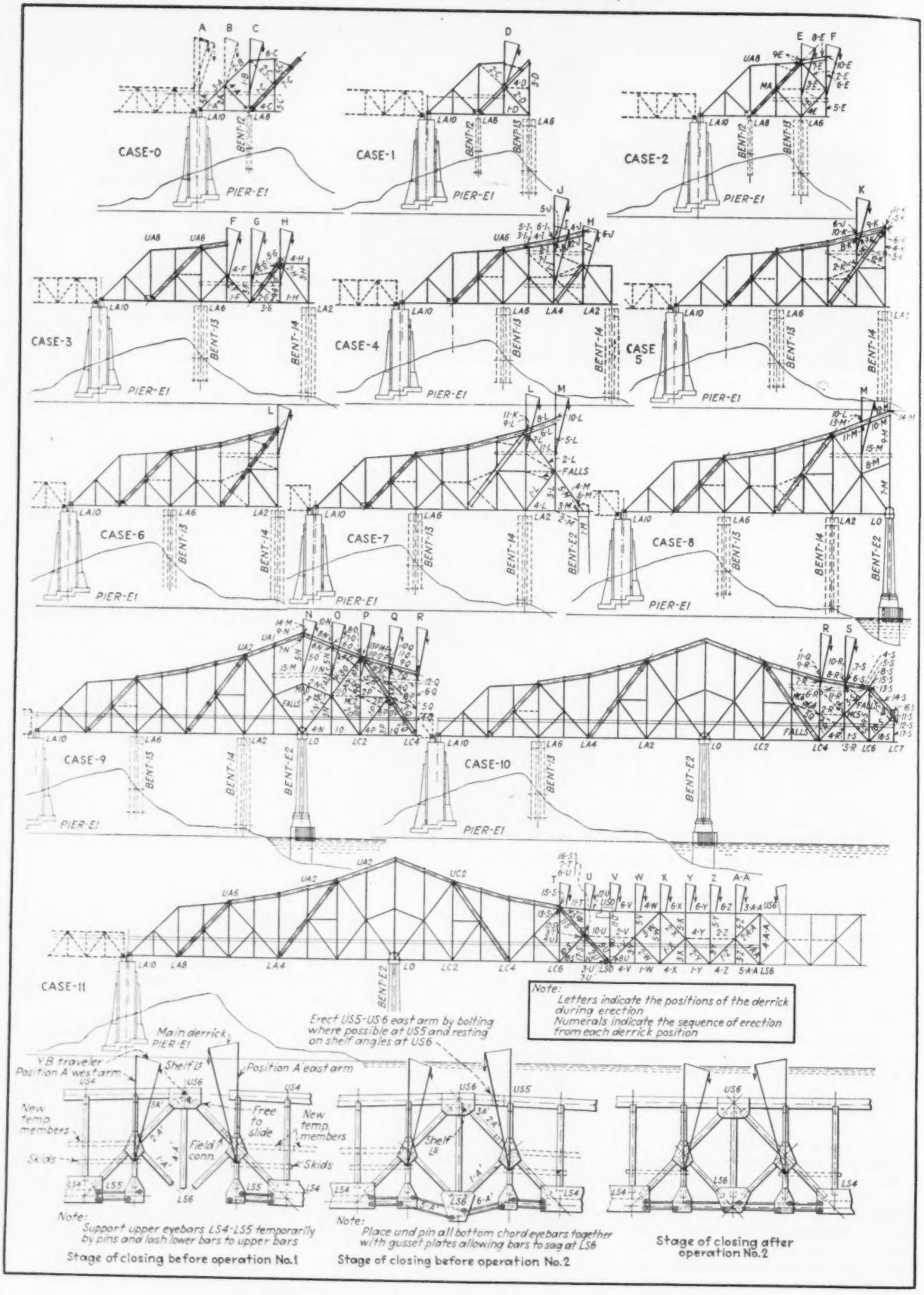


FIG. 8—SEQUENCE OF ERECTION OPERATIONS ON EAST BAY CANTILEVER BRIDGE

erection of the Yerba Buena spans had sufficient capacity to erect the members of the suspended span. Therefore when the guy derrick traveler reached the east end of the west cantilver arm, it was dismantled and re-erected at pier *E*-4. From this point this traveler worked through to the center of the suspended span; the west half of the suspended span was erected by the Yerba Buena traveler. This procedure saved an additional heavy traveler and inasmuch as the bridge construction schedule was governed by the West Bay Crossing, the additional time was of no consequence.

The movements of the truss necessary to effect the closure of the span were controlled by three sets of two 500-ton jacks per truss located at panel points *USO* east and west and at *LA* 10 east.

Paving

At an early stage of the design, it was decided to use a comparatively light-weight floor for the upper deck roadways, and an arbitrary weight limit of 60 lb. per square foot was established. After an investigation of the various types that would come within this limit, the designers concluded that a light-weight concrete floor would be more economical in first cost and in maintenance than any of the other possibilities.

The aggregate consists of a shale which is crushed, pugged, cut into pellets and then burned in a rotary kiln. Natural sand is used for the finer particles of the aggregate. When mixed with six sacks of cement, the resulting concrete has a wet weight of 100 lb. per cu.ft. and a 28-day strength of 3,000 lb.

The roadway slab on the upper deck is 6 in. thick and is reinforced in both directions. Longitudinal reinforcing consists of ½-in. rods on 6-in. centers. Reinforcing transverse to the bridge centerline consists of welded trusses spaced 6 to 9 in. apart. Top and bottom chords of the trusses are made of two ½-in. round bars; the truss bracing system is a $\frac{7}{8}$-in. round bar bent to make 45-deg. angles between the two chords to which it is welded at each intersection. These welded trusses have an over-all depth of 4½ in. and a length equal to the roadway width. To hold them firmly in place during pouring operations they were welded to the supporting stringers, which are spaced on 6-ft. centers.

The upper roadway slab was placed in two operations. In the first operation the light-weight concrete was placed in the forms, compacted by a vibrator-equipped finishing machine and screeded ½in. low by the same machine. Before the concrete had taken its initial set it was covered by a mortar topping and again vibrated, screeded and belted by the finishing machine. The results with this pavement have been extremely satisfactory in every particular.

The lower deck pavement is designed for heavy trucks. The designers considered the light-weight floor somewhat experimental and therefore the lower deck pavement was designed with a 6½-in. slab of standard concrete. The reinforcing steel and methods of placing were as above described for the upper deck except that the concrete was placed in one layer.

Personnel

The contract for the superstructure of the East Bay Crossing was held by the Columbia Steel Co. of which Ambrose Diehl is president. The late E. J. Schneider was succeeded by J. R. Fox as contracting manager. The steel west of pier *E*-4 was fabricated and erected by the American Bridge Co. of which C. S. Garner is general manager of erection and H. C. Hunter is western erecting manager. Steel for the spans east of pier *E*-4 was fabricated and erected by the bridge and fabrication department of Bethlehem Steel Co. for which company D. S. Gendel is general manager of erection, A. F. McLane, general manager of erection for the Bay Bridge, and H. A. Schirmer, resident engineer. The concrete paving was included in the general contract and was sublet to Bates & Rogers with R. Rasmussen as superintendent of construction. The personnel of the California Toll Bridge Authority was given in ENR March 22, 1934, p. 377.

Full Circle Tunnel Lining Placed in a Single Pour

Form traveler 160 ft. long aids completion of 70-ft. lengths of concrete lining as single operation in 10-ft. tunnel on Colorado River aqueduct distribution system

THE DISTRIBUTION SYSTEM of the Colorado River aqueduct includes a tunnel of 10-ft. inside diameter passing under the residential district of Pasadena. Requirements to be met in placing concrete lining in this tunnel made it desirable to use equipment and methods not common in tunneling practice. Primarily, these are: forms made up in completely circular panels with which a 70-ft. length of lining can be placed in a single pour; methods of bending the reinforcing steel to the required radius in the tunnel and close to the scene of operations and, finally, a working schedule controlled by the necessity of avoiding noise during hours of the night when the residential district was not to be disturbed. Incidentally, these conditions automatically limited the daily advance which the contractor could make and since there was no opportunity for profits resultant from speed, it was incumbent upon him to work out a construction schedule such that any bonus to be earned would accrue from a low cost of carrying on the work.

This tunnel originally was to have been driven as an open cut (the overburden is 40 to 80 ft.) but later it was decided that there would be less interference with street traffic and less disturbance of the residential district if the workings were kept entirely underground. This program has worked out well in several ways and record progress was claimed in the driving operations (*ENR*, Oct. 10, 1935, p. 513).

To the cast of an access portal in Arroyo Seco, which lies toward the westerly side of the city of Pasadena, this part of the aqueduct distribution system is in almost continuous tunnel for a length of about 5 miles. The amount of concrete required for the lining averages about 2¼ cu.yd. per foot. Reinforcing steel, consisting principally of 1¼-in. square bars, amounts to about 650 lb. per lin.ft. For purposes of contract award, the tunnel lining was divided into two sections and lining equipment of similar type has been used on both contracts. In some respects this equipment is similar to that used in the Lake Cushman hydro-electric power tunnel built by the city of Tacoma some six years ago but in many particulars it represents an advance developed recently for work of this type.

Essentially the form set-up consists of a series of 5-ft. panels completely circular when jacked into place, but hinged for convenience in collapse and movement. A 70-ft. length of these forms is assembled on a traveler in which there is a truss 160 ft. long carrying an elevated track for moving the forms. The truss is supported at each end on four-wheel trucks which move on tracks in the tunnel invert. This great length of the supporting truss makes it possible to place the forms for a completely circular pour in a 70-ft. length of the tunnel and later to move the same forms ahead to a new set-up without changing the traveler position. The traveler is moved ahead of the forms after each pour. The sequence of operation is based on the

program of completing one of the 70-ft. pours each week day, six times a week. During the night no concrete mixers or cars are operated but preparatory work and preparations for the next pour are carried on.

The 70-ft. length of forms which is set up at one time consists of fourteen 5-ft. panels or ring sections each constituting, when jacked out into position, a completely circular section of lining forms 10 ft. in diameter. Each panel consists of five sections connected by hinges. The arch section is the supporting unit; from either side is hinged the wall or side sections and these in turn are hinged along their lower edges to the invert sections. The form panels are faced with steel plates ¼ in. thick curved to a 5-ft. radius.

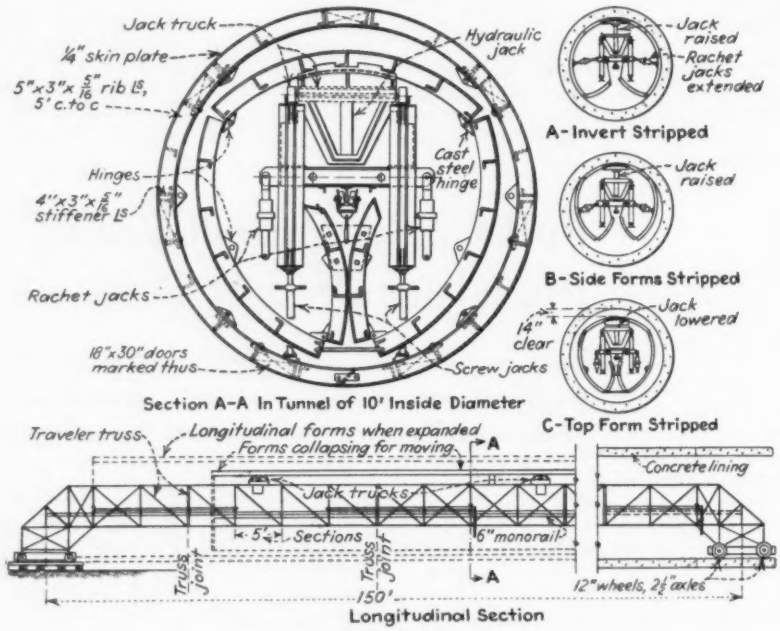
Alternate ring sections have seven openings; one in the arch, two in each side and one in each invert section. These openings are 18x30 in. in size and are used for inspection and to aid in working the concrete into place. As the fresh concrete level rises they are closed by doors which are fastened firmly in place with tapered wedges.

Each 5-ft. panel is bolted to the adjoining panel so that the entire 70-ft. length functions as a unit. However, any individual ring section can be unbolted from those adjoining and can be handled as a separate unit in removal from the complete assembly or for a separate and independent set-up on curves.

An essential part of these forms is the 160-ft. traveler on which they operate. It consists of two steel trusses 5 ft. deep fastened together by cross-bracing so that the assembly resembles a box girder with 5x4½ ft. cross-section. This truss assembly weighs 20 tons and is supported on a four-wheel truck at each end. There is a clear length of 140 ft. between the trucks, thus providing space for a 70-ft. form section to be moved ahead to a new position without changing the setting of the traveler.

The trucks under the traveler have 12-in. flanged wheels, 2½-in. axles and operate on a track of 24-in. gage. On top of the truss, angles running the full length of the traveler constitute a track for the cradles of four 15-ton jacks. These jacks thus can be moved along the traveler freely and are used for supporting and carrying the forms when a move to a new set-up is being made. Ordinarily the jacks are equally spaced when the 70-ft. length of the form assembly is being moved.

When forms are to be moved the first operation is to unbolt the center invert sections for the full length and pull them up to the girder with chain



TUNNEL LINING FORMS shown in section and elevation. With this assembly a completely circular section 70 ft. long is lined in one pour.

jacks hung on the truss for this purpose. This operation is shown in section *A* in the accompanying drawing. The second step is to retract the ratchet wrenches which extend from the traveler to the side walls, thus pulling in the wall sections and stripping the side walls as shown in section *B*. The third and final stripping operation is to release the hydraulic jacks supporting the arch section which lowers the arch forms about 14 in. below the position in which the pouring took place. This condition is shown in section *C*.

With the forms thus freed from the lining and supported on the hydraulic jacks whose trucks roll along the top of the traveler, the entire form assembly can be pulled ahead by an electric hoist mounted on the traveler. Arriving at the new location, the forms are set up by the reverse process. That is, first the hydraulic jacks function to raise the arch to place, the invert panels are then lowered whereupon the wall panels swing out under the force of gravity. The walls are forced firmly into place by the ratchet jacks and finally the invert forms are bolted in place to complete the circular section. After this circular set-up is completed and before pouring commences, the screw jacks that prevent hydraulic uplift from "floating" the forms out of position in early stages of pouring are put in place between the under side of the traveler truss and the invert panels. These screw jacks are spaced about 10 ft. along the full length of the 70-ft. assembly except at the ends where a screw jack is placed under each truss about 6 ft. in from the end of the assembly.

The advancing end of the traveler runs on a 24-in. track in the center of the tunnel. This track is not set to exact grade as a variation of a few inches can be taken care of by the hydraulic jacks. The rear end of the traveler moves on a track section supported on the previously stripped concrete invert. For this track special ties are used cut on a 5-ft. radius out of 6x12x48-in. timbers. These ties are laid on the concrete every 4 ft. Under the pouring schedule used on this tunnel it is not necessary to place this invert track until about 16 hours after the concrete has been poured. The load distribution is such as to keep loads on concrete down to about 20 lb. per sq.in. After the forms have been entirely filled there is no further need for any of the lining supports. The screw jacks beneath the traveler are removed as are the hydraulic jacks against the arch and the ratchet jacks against the sides, thus completely freeing the traveler from the forms. The traveler then is immediately moved ahead 70 ft. by means of the electric hoist and the next succeeding cycle of operations can begin.

Placing concrete

Concrete is delivered to the forms from a concrete jumbo carrying a 1½-cu.yd. mixer and a pneumatic placer from which a 6-in. discharge pipe leads into the form along the arch. At the start of pouring in each 70-ft. section the discharge end of the delivery pipe is placed in the far end of the form, about 1 ft. from the face of the preceding pour, and the operator manipulates the air controls so as to ease the batches

into place until the forms are filled up to this position of the discharge pipe and the pipe end becomes embedded in fresh concrete. Thereupon the concreting unit begins to back away and this gradual movement continues so that the discharge end of the pipe always is kept embedded (sometimes as much as 10 ft.) until the entire 70-ft. length of form has been filled.

Before freshly placed concrete begins to reach the open end of the 70-ft. section, a bulkhead is bolted on to retain concrete as it arrives at this end. The bulkhead contains a 6-in. water stop and also has a keyway to bond the cold joints. As the concrete is placed vibrators fastened to the inside of the form panels are operated. Two such vibrators are used, clamped to longitudinal stiffeners in the forms. These are unclamped and moved along at intervals to keep them near the line of the concrete slope. The contractor reports that vibration of 10 sec. per batch is about the maximum for best results. Excessive vibration is said to cause a tendency to segregation.

Before pouring concrete on curves it is necessary to make a special set-up of the forms. On a curve with a 12-deg. central angle, a 100-ft. radius and affecting 22 ft. of tunnel, the forms were separated into four 5-ft. sections, and each one was accurately placed in position and fastened there to constitute a 5-ft. tangent. The edges of adjoining panels were placed in contact at the inside circumference. In the gore or opening on the outer circumference the space was filled with wooden fillers cut on a band saw exactly to fit the opening of variable width. These fillers were bolted firmly to the ribs of the panels.

As a support for these 5-ft. panels a 40-ft. section of the traveler was separated from one end of the traveler and with its forward end supported on a flat car, was set up across the center of the curve. In this position ratchet jacks and screw jacks could be used to hold the panels in circular shape just as they did on tangents.

The first operation in preparation for a new form set-up is to remove the track from the invert along which the forward trucks supporting the traveler have just passed. The tunnel is then ready for the invert to be graded by hand to the required level. The material traversed by this tunnel is a sandy or gravelly clay and part of the construction program involves the removal from the invert by the lining crews of 30 yd. of excavation per 70-ft. length of forms. This work takes the invert, at its center, to a depth of 26 in. below the foot blocks of the steel ribs in the temporary lining. The excavated material is moved in wheelbarrows to the muck train where it has to be rehandled by men with shovels.

With the excavation finished, the invert is worked down to fine grade with the aid of a template set from grades marked by engineers on the ribs of the temporary lining.

Placement of reinforcing steel is next in order. About 23 tons of reinforcing goes in each 70-ft. section. Most of this is in the 1¼-in. squares which come into the tunnel in straight pieces 22 ft. 10 in. long. Two of these pieces, when bent to the proper curve, make up each of the complete circles which are placed on 5-ft. centers. By bringing the bars into the tunnel before bending them, a considerable quantity can be stored without interfering with the lining operations and the inconvenience of transporting curved steel is avoided. The steel bender, kept in the tunnel at a point conveniently near the lining operations, is mounted on a turntable which turns at the same time that the bending operation goes on, thus making it possible to bend the 22-ft. 10-in. bars to a 5½-ft. radius in a tunnel only 12 ft. wide.

The bars making up the semi-circular curve in the upper half of the tunnel are placed first. These bars are slung from the ribs of the temporary tunnel lining. Bars for the lower half of the tunnel are placed next and are supported on concrete chairs laid on the invert in advance. Where the two semicircular portions of the reinforcing overlap they are wired together. Finally the longitudinal tierods ¾ in. in diameter, spaced 2 ft. apart circumferentially, are placed and wired to the circumferential rods.

Daily program

The day shift comes on at 8 o'clock in the morning on a work schedule that ordinarily carries through to 2:30 or sometimes to 4 o'clock in the afternoon. This crew is through for the day as soon as it has placed the 145 cu.yd. of concrete required for the 70-ft. length of form. It is made up of ten men, including the compressor man.

The swing shift comes on about 2 o'clock in the afternoon and works until its schedule is completed. It cleans up the 70 ft. ahead of the section just poured, does the excavation of the invert already mentioned, moves the air and water lines and places the track on which the rear truck of the traveler is to move. This crew is made up of ten men, including one on sprinkling concrete stripped the previous day. This shift usually works about 6¾ hours.

The steel crew of twelve men comes on at 4 p.m. and ordinarily finishes at 12 midnight. This crew places all steel and completes the assembly of reinforcement ready for the forms to move into place.

The form crew which comes on at 12 midnight consists of six men, including one on sprinkling. This crew moves the forms, scrapes them thoroughly, gives the faces a coating of oil and completes the 70-ft. set-up in about 6¾ hours. There also are employed during the day an outside crew and a bull gang, including mechanic, electricians, etc.

Specifications for concrete in the tunnel lining call for a dry mix—the slump is about 2 in. Test cylinders have shown far higher strengths than the specifications require; in some cases strengths have ranged up to almost 4,000 lb. per sq.in. in 28 days. Cylinders from the forms (where the concrete has been subjected to the compressed air used in the placer) are reported to show a strength of about 800 lb. per sq.in. more than do cylinders taken at the mixer. One man is kept at work with a grinder smoothing off fins and edges after forms are stripped. No patching whatever has been required. Grouting is done by the district on force account basis because of the known loose character of the overburden. The grouting has averaged about 5 cu.ft. per lin. ft.

The work is being done for the Metropolitan Water District of Southern California, of which F. E. Weymouth is general manager and chief engineer. Contractors for lining the two sections of the distribution tunnel described in the foregoing are (1) Dixon, Bent Bros. and Johnson and (2) the J. F. Shea Co. Sherlock D. Hackley is superintendent of lining operations; the concrete placer, traveler and forms are patented by Roy C. Hackley.

Changes in Plan Lengthen Vancouver Bridge

CHANGES IN THE PLANS for the first Narrows bridge at Vancouver, B. C. have been approved by the dominion government at Ottawa. Under the revised plan the north tower will be moved 50 ft. inland, increasing the length of this $6,000,000 suspension bridge from 1500 to 1550 ft. This approval supersedes a previous change which would have moved the north tower 100 ft. inland and the south tower 50 ft. off shore; this plan was abandoned when it met with opposition from navigation interests. The change has been made, it is understood, because exploratory drilling revealed better rock foundation inland from the originally planned location of the north tower.

In addition to the main suspension span, 1550 ft. long, with a 200 ft. clearance above high water, there will be a 3,000 ft. approach on the north shore. The bridge will carry a 29-ft. roadway and two 5-ft. sidewalks.

Monsarrat & Pratley, consulting engineers, Montreal, are the designers of the bridge. W. F. Way has been selected by Stuart Cameron Company, Ltd., of Vancouver, B. C., contractors for the foundations, to superintend its work.

CONTROL OF ROCK DUST IN CONSTRUCTION—I

Health and Medical Aspects Of Silicosis

By A. J. Lanza, M.D.
Assistant Medical Director, Metropolitan Life Insurance Co.

CONTROL OF ROCK DUST *for the prevention of silicosis is one of the most serious problems confronting the construction industry today. Confusion and lack of knowledge accentuate the constructor's difficulties. His knowledge of silicosis is largely that presented by lurid press reports of the ill-famed Hawks Nest tunnel case; in literature he finds much devoted to the medical side of the subject and all too little regarding practical control of dust on the job; he has no representation on the Secretary of Labor's dust control committee, yet he will be subject to its findings and recommendations; and finally, he is faced with a multitude of strange, new laws and regulations governing silicosis control and compensation. To clarify the situation for the constructor,* Engineering News-Record *is presenting a series of articles on dust control in construction, the first of which follows. Dr. A. J. Lanza, an outstanding international authority on silicosis, starts the series with a discussion of the health and medical aspects of the disease. Subsequent articles will discuss practical rock dust control and prevention methods, and legislative and compensation developments.*

—EDITOR

THAT CERTAIN KINDS of dust cause damage to the lungs when inhaled has been known for centuries. Even the ancients knew that there was a definite relationship between mining in certain kinds of rock and a disease which was evidenced by short-windedness, which they called asthma. A number of other terms have been used to describe this condition, such as miner's consumption, miner's phthisis, grinder's rot, and potter's asthma—all meaning the same disease which is now generally known throughout the world as silicosis.

In modern times, the introduction of tools operated by compressed air, used for drilling, cutting, and chipping rock, has caused dust disease of the lungs to become fairly wide-spread and to be an important source of disability among industrial workers. There is only one kind of dust that produces a typical disease, with characteristic symptoms, which we call silicosis, and that is dust containing free silica (SiO_2) in a very finely divided state. Dusts containing silica in combination, with the exception of asbestos, are not, as far as we know, responsible for any appreciable amount of disability.

The human body has a very efficient protective mechanism against inhaling dusts in the atmosphere. The construction of the nose, the naso-pharynx, and the wind-pipe are such that these passages filter out from the air much of the foreign material that may be in it. It is only when this protective mechanism is subjected to continuous severe strain that it breaks down.

Development of the disease

Silicosis is a disease which comes on very gradually and, in most forms of industrial exposure, takes from ten to fifteen and even twenty years to develop. This is one of the important facts about silicosis which should be kept in mind.

A great deal of laboratory research has definitely established that dust particles, to get into the lung, have to be exceedingly small, so fine, indeed, that they can traverse the terminal air passages or bronchioles and thus reach the air lobules where the physiological process of breathing takes place. Most of the dust particles which get into the lungs are between one and three microns in size (a micron is 1/25,000 in.). At the most, 10 microns would be the largest size which will reach the lungs. The second important fact, therefore, to remember about silicosis is that silica dust must be exceedingly fine before it can penetrate the lungs.

Furthermore, silica dust is harmful in proportion to the amount of silica it contains. Obviously, the higher the percentage of silica, the more dangerous the dust, so that we see the most aggravated or what is sometimes called the "classical" form of silicosis under those circumstances where the dust is almost pure silica (chert, flint, quartz). We base our estimation of the severity of the silica dust hazard in any given situation upon the amount of silica contained in the dust and upon the amount of dust in the air.

For determining the amount of dust in the air, the standard method developed by the U. S. Public Health Service and the U. S. Bureau of Mines is used in this country. The instrument used is known as the impinger and the results obtained are remarkably accurate. Other instruments are in use, but in this country the impinger is standard.

When dust samples are being taken in industrial establishments, the result is expressed in millions of particles under ten microns in diameter per cu.ft. of air. One advantage of the impinger is that it can operate continuously, making it possible to obtain very large air samples, which in turn tends to cut down the margin of error. The instrument is simple, can be readily moved and set up, and as a rule is placed on a level with and near the faces of the workmen, so as to sample the actual air which they inhale.

We have no hard and fast limits of air dustiness, with respect to what is safe or what is dangerous from the health viewpoint. The various studies which have been made, however, seem to indicate that if the dust contains any appreciable amount of free silica, the dust count should be kept below 10,000,000 particles per cu.ft. of air. Even 10,000,000 particles of a highly siliceous dust is not a safe limit. Dust sampling requires a careful and accurate technique and considerable experience is necessary before consistently reliable results are obtained. Industries are beginning to train laboratory technicians to do this work, as in order to keep a dust hazard under control, periodic checking is essential.

It used to be supposed that the harmful effects of inhalation of silica dust was due to the hardness and sharpness of the dust particles themselves. We now know that this is not so. We do not know exactly how the dust acts in the lungs, but the indications are that silica is a tissue poison. Whether it causes its effects by going into solution or partial solution in the lung tissues is still a matter for further study.

Besides its direct action upon the lung tissue, one of the effects of continued exposure to silica dust, which has

been noted in the various parts of the world where this disease has been studied, is that it causes the individual to become peculiarly susceptible to tuberculosis. The more severe the silica dust exposure, the more apt is tuberculosis to result. While silicosis may cause disability and death in the absence of tuberculous infection, it has not been frequently observed to do so in industrial experience.

Silicosis and tuberculosis

While it is possible for the individual with silicosis to contract other types of infection, tuberculosis is the only one of real practical importance. Those individuals who die from silicosis are, in the great majority of cases, found to have tuberculosis also. Just what is the relationship between these two diseases is as yet unknown, but it would seem as if the presence of silica in the lung tissues makes a favorable situation for the growth of the germ of tuberculosis. When an individual with silicosis develops tuberculosis, the latter may be essentially chronic and run on for a number of years, but if the exposure to silica has been very severe the progress of tuberculosis may be quite rapid and cause death in a few years after the infection has first become manifest.

As would naturally be expected, silicosis comes on gradually and insidiously. The first symptom is a shortness of breath on exertion. This shortness of breath increases slowly but surely, and when the disease is well established will impair working ability considerably or even cause total disability. In the early and moderately advanced stages, the affected individual looks well, may show a tendency to put on weight, and (aside from the distress caused by physical exertion) feels well. This short-wind, or *dyspnoea* as the doctors call it, is a very clear-cut and definite symptom. In well established cases it is notable because it seems to be so out of proportion to the general healthy appearance of many of the patients. There is apt to be a dry cough and a tendency to "catch cold" frequently. Occasionally, there may be some spitting of blood but it is unusual to have a frank hemorrhage such as we see in consumptives.

As the disease progresses, pains in the chest are common and may give rise to considerable discomfort. When tuberculosis has become planted upon silicosis, we may see the symptoms commonly associated with the former disease, that is, profuse expectoration, loss of appetite, loss of weight, night sweats, and an afternoon rise of temperature. Sometimes these symptoms come on with dramatic suddenness and the patient goes rapidly downhill. Even when it is obvious from the symptoms and general condition of the patient that tuberculosis is present, the germs of tuberculosis may not be found in the sputum until a relatively short time before death.

Where the exposure to silica dust has not been very severe, symptoms may not show up for many years; there may be some short wind, but it does not develop to a point sufficient to impair working ability. With this type of exposure, we frequently see men with silicosis still able to carry on their work in good shape, many of them having reached their sixties and seventies. In other words, where the silicosis hazard is mild, it may not appreciably shorten the individual's working life. However, it should be remembered that if we study the mortality of those exposed to what might be termed the less severe types of silica exposure, we will find that the mortality from tuberculosis among them is greater than that for wage earners as a whole.

PERTINENT FACTS ABOUT SILICOSIS

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Only dust containing free silica can produce silicosis.

The disease develops slowly, usually an exposure of ten to twenty years is required to produce silicosis.

Silica dust is harmful in proportion to the amount of free silica it contains.

Only silica particles under 10 microns in size (microscopic) are harmful to the human lung.

The exact action of silica dust on lung tissue is not as yet known. Silicosis alone rarely causes serious disability; disablement usually results from a combination of silicosis and tuberculosis.

The X-ray is the only positive method of diagnosing silicosis.

Diagnosis

If we examine a man who is in the early or moderately advanced stage of silicosis, we may find little on physical examination to confirm the diagnosis. He may exhibit no physical signs other than somewhat impaired breath sounds. If the man is heavily built, with large muscles, it is difficult to get any definite impressions from an ordinary physical examination. For this reason, we have to turn to the X-ray film in order to establish a diagnosis. The appearance of silicosis on the X-ray film is definite and clear-cut and should not be confused with other diseases of the chest.

When making examinations of men among whom it is thought that there might be silicosis, it is exceedingly important to get a careful, accurate, occupational history. Not every man who is short-winded has silicosis, even though he may have been exposed to varying quantities of silica dust at one time or another. The diagnosis is based upon a history of exposure to silica dust together with the characteristic X-ray film. The physician should know the severity of the exposure and the length of time during which the individual has been exposed. A careful weighing of these facts enables him to make a diagnosis. If the X-ray film does not show the characteristic appearance of silicosis, a positive diagnosis cannot be made.

As a rule, when the silicotic has also become tuberculous, we can determine that fact from the X-ray film. Occasionally the examining physician will see films from which it is not possible to state with certainty whether tuberculosis is or is not present. It should be remembered that the absence of tuberculosis germs in the sputum does not rule out tuberculous infection.

For accurate and satisfactory X-ray diagnosis of silicosis, it is essential to have a good apparatus and to use it properly. In the same individual we can obtain films quite dissimilar in appearance by varying the time of exposure and the intensity of the current; consequently, a correct technique is all important. Much experimentation and study have indicated that for uniformly satisfactory results, an X-ray apparatus should be used which is capable of taking a film at a distance of from 48 in. to 72 in. with an exposure not slower than 1/10 sec.

We cannot obtain satisfactory films unless the patient holds his breath, and the faster we can "shoot" him the more apt we are to get a good film. While a well-advanced case of silicosis can generally be determined from a single film, it is better to obtain stereoscopic films; we are able to view two exposures in a suitable viewing box, which gives us the third dimension, namely depth, and greatly lessens the chance of error, especially in early cases where precise diagnosis is so important.

It should be remembered that most of us who are past our fortieth year will show various lines and shadows in the X-ray films of our chests which do not indicate disease and are compatible with good health. Consequently, he who takes it upon himself to interpret X-ray films of dust diseases of the lung should be thoroughly familiar with the variations in the appearance of the ordinary, healthy chest.

If a man has early silicosis and is removed from further dust exposure, his disease may not progress and may clear up somewhat. If the silicosis is well

established, that is, if there is any considerable amount of damage to the lungs, there is a tendency for the silicosis to progress even after removal from further dust exposure. There is some question as to whether in these cases the silicosis actually does progress unless the patient is also infected. Where there is a marked progress, after exposure to dust has ceased, it's probable that tubercle infection is present.

Hazardous trades

It is a matter of interest to know what trades or occupations are exposed to the silica dust hazard and the number of individuals who might be included in these occupations. The following data are taken from an article published by Lanza and Vane, based upon various studies and reports, including a report by Matthew van Siclen of the American Institute of Mining and Metallurgical Engineers and U. S. Census reports.

It was estimated that approximately 62,000 men engaged in the metal mining industry were exposed to varying degrees of silica dust. Of anthracite miners, approximately 30,000 are exposed to silica dust. The quarrying of granite, tap rock, slate, sandstone, diatomaceous earth, ganister, glass sand, abrasive materials and the like comprises about 22,000 more, so that in these various types of mining and quarrying there are about 115,000 workers exposed to silica (not, by any means, all those engaged in these industries).

In smelting and refining, in foundries, potteries, glass works, in plants manufacturing granite, slate and marble products, together with those employed as grinders, buffers, sand-blasters, and vitreous enamelers, it was estimated that in this group of manufacturing industries, there were about 325,000 workers exposed to silica dust.

There may be a silica dust hazard of greater or less extent connected with the manufacture of sandpaper, hones, mineral fertilizers, clay products, cordage and jute goods. Many branches of construction work require considerable drilling in siliceous rock. This is particularly true in Manhattan Island, New York City. Laborers and helpers in general construction, in road and street construction, together with railroad workers and those in public service, many of whom are engaged in construction work, are also in some instances exposed to a silica dust hazard. The combined total of workers employed in these miscellaneous industries numbers about 2,000,000, of whom probably only a small percentage are exposed to silica. If we apply the conservative figure of 5 per cent, we get 100,000 more to add to our total estimate. All in all, we get a figure of about 500,000 workers exposed to the silica dust hazard. It is more than probable that this figure is very conservative; it does not take into account large numbers of individuals who have worked in silica dust industries and are now engaged in other occupations.

Inasmuch as silicosis is not a reportable disease and on death certificates and in vital statistics usually is classed with tuberculosis, there are not available any statistics on deaths from silicosis from which could be based estimates of the exposure.

When silicosis was first studied and investigated, it was customarily divided into stages for compensation and administrative purposes. In this country, three stages were commonly described —first, second, and third: the first being early silicosis with no disability; the second, more advanced with partial disability; and the third, far advanced with total disability. Tuberculosis might be present in any stage, particularly the second and third. This classification has been largely outmoded, due to greater knowledge and more refined methods of diagnosis. A description of the disease is now based on the X-ray appearance, correlated with the underlying pathology in the lung causing such appearance.

The estimation of disability in silicosis is in far from a satisfactory state, and this, together with the variety of legislative attempts to deal with compensation, is causing a confusion in administering compensation. It is probable that the experience of the next few years will clarify and adjust these various differences. At the same time, consistent attempts to control the dust hazard will tend to prevent the occurrence of severe types of silicosis.

Material and Equipment Costs on WPA Projects

FIGURES recently released by the Works Progress Administration show that from the start of the WPA program, July 1, 1935, through August 31, 1936, expenditures for materials by the WPA and by the sponsors of projects amounted to $210,710,000. Rentals of equipment by the Administration and by the sponsors, total $128,530,000.

A breakdown of cost items is shown in the accompanying tables. The figures cover expenditures by the WPA and by sponsors from July 1, 1935 to September 1, 1936.

A tabulation of the cost to the Administration and to project sponsors of equipment rentals and services from July 1, 1935 to August 1, 1936 is given below. The figures include a small but indeterminate amount for the personal services of non-relief operators of the equipment, where it was not possible to separate payment into the categories of personal services and equipment hire.

WPA EQUIPMENT RENTALS

Trucks and Vans	$74,702,206.00
Teams and Wagons	7,659,471.00
Buses	969,349.00
Passenger Vehicles	2,508,498.00
Paving Machinery and Equipment	13,984,396.00
Other Machinery and Equipment	17,913,909.00
Space Rentals and Services	2,748,905.00
Other Rentals and Services	5,520,814.00
Miscellaneous	2,522,567.00
TOTAL	$128,530,115.00

WPA EXPENDITURES FOR MATERIALS

Construction Materials, excluding iron and steel		$106,512,571
Lumber and its products (excluding furniture)	$25,681,144	
Paints and varnishes	3,920,024	
Sand and gravel	13,951,348	
Crushed stone	11,416,783	
Cement	20,052,967	
Concrete products	11,586,735	
Brick, hollow tile and other clay products	12,249,507	
Stone and glass products, etc	7,654,063	
Iron and steel products, excluding machinery		46,801,127
Structural and reinforcing steel	11,664,096	
Cast iron pipe and fittings	15,277,817	
Plumbing equipment and supplies	2,345,970	
Heating and ventilating equipment and supplies	1,819,408	
Tools (excluding machine tools)	5,424,570	
Other iron and steel products	10,269,266	
Machinery and equipment		7,891,310
Electrical machinery, apparatus and supplies	3,894,566	
Paving machinery, apparatus and supplies	385,161	
Motor trucks	108,560	
Other machinery and equipment	3,503,023	
Petroleum products		23,227,909
Paving materials and mixtures, bituminous	18,743,638	
Other petroleum products	4,484,271	
Miscellaneous		26,277,076
TOTAL		$210,709,933

Firming Up Soft Shoulders With Cotton

New facts and procedure developed in Rhode Island in stabilizing sand shoulders on highways and in redressing tar roadways with a cloth and bitumen armor coat

IN TRYING OUT cotton cloth as a stabilizer of thin bituminous road surfacing the highway department of Rhode Island offers some new facts on procedure and a new use of the process for firming up soft shoulders. The larger undertaking was a resurfacing operation on a short section of Round Top road in the town of Burrillville. The shoulder surfacing was on Ten-Rod road in Exeter and as it presents the greater novelty it is described first.

Shoulder stabilization

Ten-Rod road completed last year is gravel, surface-treated with tar. The shoulders were left untreated and being very sandy have been a serious traffic hazard and this year it was planned to give them a bituminous surface treatment. With the example of the cloth-reinforced Round Top road in mind and cloth being at hand the thought occurred of using cloth-reinforced construction on the soft shoulders. The accompanying views indicate the procedure adopted.

In general the cloth covered only the ordinary shoulder width but on certain sections in cut it was carried out to the toe of the slope to prevent erosion. The method of treatment was to apply ½ gal. per sq.yd. of M.C.2 (cutback asphalt) to the sand and then to lay the cloth, after which the cloth was given a sprinkling of ¼ gal. per sq.yd. of the same M.C.2 oil and a liberal coating of sand. A second ¼-gal. treatment and sand blotter followed on most sections. So far the results are favorable; the shoulder treatment has kept all vehicles from stalling although there was at first some rutting by trucks which had to be ironed out by rolling. It is believed that such trouble will disappear as the asphalt sets up hard.

Travel-surface treatment

The Round Top road was originally designed and let to contract as a surface-treated gravel construction according to the standard specifications for this type of pavement in use by the state division of roads and bridges. This pavement consists of 8 in. of gravel built up in two courses on a prepared subgrade. The first, or bottom course, is 5 in. of graded gravel and the top, or wearing course, is 3 in. of graded gravel. The top course is treated with ¾ gal. per sq.yd. of 13-18 tar as a penetration coat and sealed with ¼ gal. per sq.yd. of 25-35 tar and then covered with about 20 lb. of fine, sharp sand.

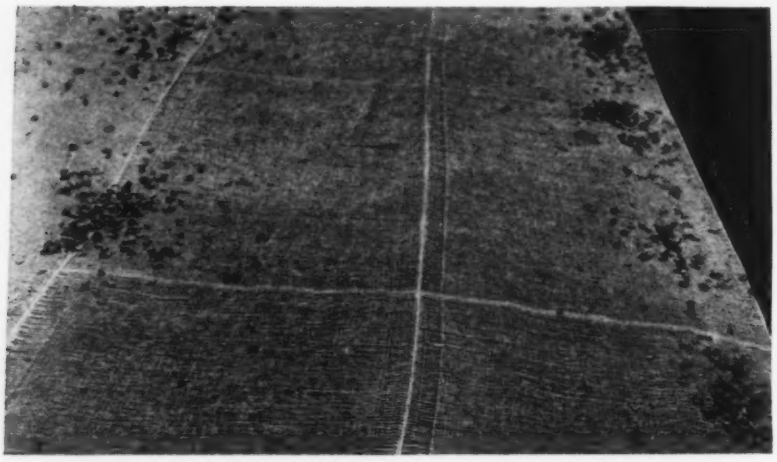
In this experiment, making use of the cotton cloth, it was decided to use 8-pick fabric; this is an open weave with about 8 threads to the inch. This fabric was placed directly on the top or wearing course of the gravel road after it had received its initial application of ¾ gal. per sq.yd. of 13-18 tar and had lain at least five days to one week exposed to the weather. The surface was covered with the fabric rolled out longitudinally; as the cloth was only 4½ ft. wide, it gave when lapped 2 in. a total width of 16 ft., which left a 1-ft. strip on each side of the surface which did not have any fabric covering.

No difficulty was experienced in unrolling the fabric as it was a clear and comparatively windless day. To keep the edges from moving or curling small quantities of sand or chip stone were spilled along them. After the fabric was down, trucks, loaded and empty, and also passenger cars ran over it at speeds of 10 to 15 miles per hour, with no particular detrimental results. The work was carried out in two phases as follows:

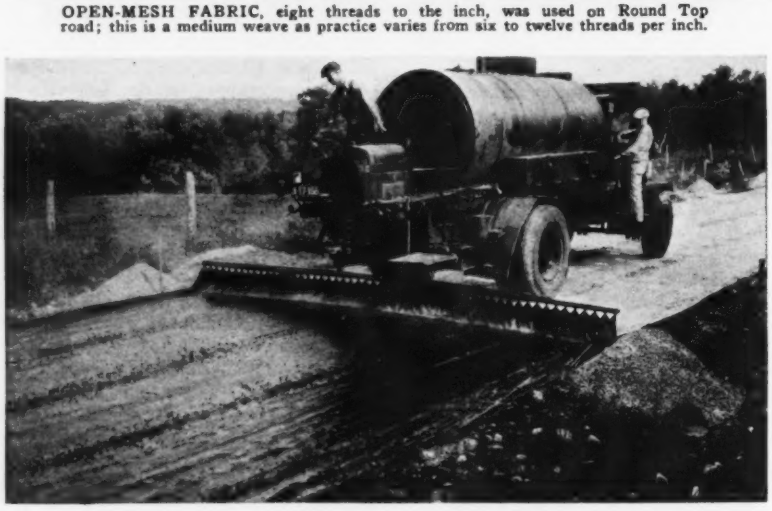
Sand Coated Fabric—The fabric after being laid was covered with ⅛ gal.

SPREADING CLOTH from a spool on a truck to stabilize the soft shoulders of a surface-treated gravel road; note that cloth is carried out nearly to the toe of the side slope in cut.

CLOTH UNROLLED by hand; four strips of 4½ ft. cloth lapped 2 in. covered 16 ft. of an 18-ft. road.



OPEN-MESH FABRIC, eight threads to the inch, was used on Round Top road; this is a medium weave as practice varies from six to twelve threads per inch.



ONCE TACKED DOWN on the prime coat the cloth is traveled over by the distributor truck without injury.

per sq.yd. of 25-38 tar; this application served to soak the cloth for preservation and adhesive purposes. There was a marked absorption by the fabric, but it did not take the complete ⅛ gal. as plenty was left on top. The appearance of absorption was somewhat deceptive as tar, after it had gone through the meshes, could not be readily seen free on the surface. However, even in the spots where there appeared to be no free liquid the tar had apparently got under the fabric and could be forced back up through it by slight pressure.

The initial ⅛ gal. per sq.yd. application was immediately sanded lightly with about 10 to 12 lb. of sand per square yard. After this sanding another ⅛ gal. per sq.yd. of the same quality tar was immediately applied and covered with 20-25 lb. of sand per square yard, and no further treatment was applied. While the amount of sand may seem excessive for the gallonage of tar, it was used in an attempt to build up a mat on the cotton fabric as a protection against actual contact of the cloth with traffic wear. On inspection on the day following the treatment as outlined, it appeared that no bad results need be anticipated from the apparent large amount of sand used and that the fabric was completely covered by good seal of sand and tar.

Stone Coated Fabric—After being laid, the fabric was covered with 6/10 gal. per sq.yd of Binder A (150-210) applied at 200 deg. F. This coating served to penetrate the fabric and act as a preservative for it and as a binder for the stone chips. These chips were applied immediately after the tar at the rate of about 25 lb. per sq.yd. It was intended to roll the chips the same day but as some seal coat had been applied on a portion of the surface about 1600 ft. in length between the location of the roller and the location of the stone chips it was found upon trial that it was not feasible to put the roller over the fresh seal that evening. The following day the stone-chip-covered section was viewed and it was found that the chips were being embedded in the tar by traffic and the roller. More stone was considered advisable in some sparsely covered patches. The tar was still tacky and oozy and the stone could not be forced into it by pressure. There was no particular evidence of fracture or cutting of the cloth by stone chips.

An analysis of the approximate cost of the two types of surfacing follows:

1. Laying cotton cloth and sanding; 600 sq.yd. of cloth used:

Labor 12 hr. at $0.50	6.00
Truck 1.5 hrs. at 1.75	2.63
Driver 1.5 hr. at 0.60	.90
	9.53

$\frac{953}{600}$ = $0.0158 per sq.yd. over contract price of $0.42

2. Laying cotton cloth and spreading stone chips; 1,000 sq.yd. of cloth used:

Labor 20 hr. at $0.50	10.00
Truck 2.5 hr. at 1.75	4.37
Driver 2.5 hr. at 0.60	1.50
Roller 4.0 hr. at 2.50	10.00
Stone 21.05 tons at 3.10	62.26
Binder A 529 gal.	63.48
	154.61

$\frac{154.61}{1000}$ = $0.15461 per sq.yd. over the contract price of $0.42.

Deadly Gas Formed in Water Tunnel

A STRIKING EXAMPLE of the potentialities of hazard from use of chemicals in water purification may be found in a recent experience at Chicago where evidence was uncovered that severe headaches and coughing among men working in the basement of one of the pumping stations were probably caused by the presence in the atmosphere of a small amount of phosgene, a deadly war gas, which was carried into the station through a duct connected to a water tunnel shaft in which chlorine solution was being applied. H. H. Gerstein, sanitary engineer, Chicago water purification division, presented the following facts to the Wisconsin section of the American Water Works Association.

Tests showed the presence in the shaft of chlorine gas and an inflammable gas, the identity of which was not determined. Decreased water coverage over the ends of the chlorine solution hose because of low elevation of the water in the shaft, caused by abnormal flow in the tunnel, allowed the escape of chlorine gas, while the presence of the inflammable gas in the shaft was found to be due to infiltration from surrounding soil. Phosgene the presence of which was determined by qualitative test in the duct leading from the shaft to the pumping station apparently was formed by the combination of chlorine and carbon-monoxide gases. Fortunately the condition was rectified before any damage was done.

Better Flood Forecasting And Flood Warning Needed

Federal government should strengthen the flood-forecasting facilities of the U. S. Weather Bureau—A qualified hydrologist in each district office should be charged with responsibility for issuing advance warnings of floods.

By Robert E. Turner
Susquehanna Electric Co., Conowingo, Md.

RECENTLY *there was published in the* CIRCLE *of the United Gas Improvement Co. an article by Robert E. Turner commenting on the inadequacy of the flood forecasting and floodwarning service of the federal government and proposing means for improving that service. Because that article is especially pertinent at this time when extensive reorganization of federal departments is under consideration, the editors of* ENGINEERING NEWS-RECORD *asked permission to reprint it. The permission was granted, and subsequently Mr. Turner revised his comment. It is here presented in its revised form.*—EDITOR.

ALTHOUGH there are many projects being submitted for consideration under the federal flood control program, yet, nowhere have I seen any notice made of a matter of paramount importance, namely, a unified, adequate flood forecasting and warning service. Such a service should be considered in any national flood-control program, because not only would such a service limit to a great extent the justification for expensive flood control-projects undertaken purely for expediency, but, oddly enough, adequate forecasting facilities are required in order to operate properly the flood-control projects.

I do not mean to disparage flood-control works, but, the public mind should be disabused of the fact that after well designed flood-control works are finished, no further attention need be given to flood-producing rains. The proper operation of flood-control projects will always be dependent upon timely and accurate flood forecasts.

Flood control must stand alone

Flood-control projects should justify themselves on flood control alone, because, generally, they are contradictory to the idea of navigation and power development. Full pools are necessary to navigation and to power. Empty pools and large ones are necessary for flood control. The two things do not go together. Flood-control projects should be justified as such only by the possible saving of life, property damage, and suffering of those affected. As far as loss of life is concerned, I was told recently, by an army engineer, that the Corps of Engineers lose every year in its river work, as many lives as were lost during the floods of last spring. So, the problem resolves itself into an economic question: "How much should be spent to save how much?" To me, forecasting would minimize to a large extent property damage and suffering, and make a good substitute for expensive flood-control schemes. Certainly, a unified forecast system is of great enough importance to be considered in its proper proportion in any national flood-control program.

I can see no insurmountable obstacles to giving adequate flood forecasts and warnings at least twelve hours in advance anywhere, on any watershed; but the unified, adequate flood forecasting service necessary to do this is not in evidence now; mainly, I believe, because while such work is a function of the Weather Bureau, that organization lacks full responsibility and adequate appropriations to do the job properly. It is a service that properly belongs to the meteorological organization, because river stages are a function of precipitation, and the observing and collection of precipitation data must be carried on by the Weather Bureau for many objects other than river stage forecasting. Then, in addition, the Weather Bureau has a large and nation-wide organization functioning daily, and where necessary twenty-four hours a day, for disseminating weather information. The river information, which goes hand in hand with the former, can be handled economically and to best advantage by the same organization.

Because of the multiplicity of other duties imposed upon the field officials of the Weather Bureau, it is extremely difficult for these officials to give the requisite amount of time to the river and flood forecasts. The vital need for flood forecasting, in which the great mass of people are affected, comes so infrequently that the service degenerates because of other more popular interests demanding the attention of the Weather Bureau officials. Then, in time of need, the service is found wanting. The results are excuses. I recommend that there be placed in the district office of the Weather Bureau in each drainage system, a qualified hydrologist to devote his entire time to this work. He would be responsible, and the only responsible source, for river forecasts in that entire drainage system.

Flood forecasts, for the most part, are now made by following the gage heights of the upper tributaries, because that method will give the most certain gage heights on the main streams, both as to time and amount. Except for the effect of large tributaries feeding into the stream, this method is accurate and requires little human judgment. Certainly, the results of such forecasting by the Weather Bureau speak for themselves on the large, slowly moving, navigable streams. But, to forecast floods in the smaller, more swiftly moving streams termed "flashy", such as those draining the Appalachian range of mountains, is more difficult and requires a different method. Here, floods may occur and pass in a matter of hours, or, at least, in less than three days.

Precipitation forecasts needed

Adequate precipitation forecast is a very vital phase of flood forecasting on these flashy streams since we must, to some extent, contemplate flood warnings on expected rain, because in some cases it is only a matter of hours between the flood producing rain and the resulting flood. Quantitative forecasts of precipitation and temperature must be available to the hydrologist; at least, he must have the benefit of unofficial discussions within the organization of the Weather Bureau itself, amplifying and qualifying the published forecasts. Ten years ago, the factors necessary to make such a forecast were so problematic and uncertain that forecasts of this nature were considered impossible. Now, impetus and the data for such forecasts has come through aeronautical development. The increasing knowledge of the structure of "highs" and "lows", the process concerning their genesis, continuance, and dissipation, and the loss of precipitation causation is slowly but steadily developing the art of weather forecasting into a reasonable science. Further impetus for mastery of this subject can come from flood forecasting.

The hydrologist must have a thorough knowledge of his watershed characteristics which he can acquire only by much study, and what is almost equally essential, a personal and continuous acquaintance with the rivers themselves. The best flood formulas require human judgment in their application. The hydrologist must have a continuous knowledge of conditions as to frozen ground, snow or ice on the ground, and the saturation of the ground from previous precipitation existing on every tributary, in order to corelate these conditions

with the quantitative forecast of weather. To this end, I recommend that weekly snowfall bulletins, as issued by some Weather Bureau stations, be extended to include every watershed on which snow affects the runoff, and that these bulletins be given a more general circulation.

Precipitation rate predictions

An adequate gaging system to substantiate the forecast both as to precipitation and runoff is of course necessary, and its adequacy includes continuous communication. Not only are observations at the moment valuable, but also the rates of their changes, because peak runoffs depend greatly upon the rates of precipitation. I do not think I am too impractical when I suggest the possibility of establishing a minimum number of strategically located precipitation and stream gaging stations that will have a continuous means of communication with the hydrologist, or, better yet, have equipment for remotely recording the observations. These stream gaging stations should be protected against inundation, so that the loss of records, as experienced in the last flood, will not take place. Care should be taken in locating the precipitation stations in order to get true values of precipitation in the watersheds because at present the cooperative stations are in the main in populous areas located in the valleys, and I doubt if they give a true average.

In order to properly forecast flows in advance, it is necessary to rate all stream-gaging stations on the basis of quantity of water flowing, using the gage height only as a guide. Under the present system of forecasting by gage heights, it is necessary to wait until the water gets into the river to see the resultant gage height, and from the gage height to forecast the effect further downstream. In order to forecast floods sufficiently early, it is necessary first to forecast the quantity of water runoff, and from that the expected gage height. The United States Geological Survey has rated a great number of stream gaging stations in recent years. Instead of both organizations (Geological Survey and Weather Bureau) maintaining stream gages, I recommend that this phase of the work be turned over entirely to the Geological Survey.

Certainly, with the excellent communication facilities available today—radio, telephone, and telegraph—an adequate warning system could be devised for the dissemination of advisories and warnings when the forecasts are available, so that no one would be ignorant of the probable flood conditions. Probably the most important consideration in giving adequate warnings is to have one source of information only, for the dissemination of these warnings.

The practical result from following such a plan as I have outlined should be that the hydrologist in each district office of the Weather Bureau would know what could happen, by his personal acquaintance with the watershed and conditions existing in that area. From the quantitative forecasts from the forecast center, he could estimate what would happen and give his first advisory warning if he deems it necessary. As the forecast begins to materialize, the gaging system will start to substantiate the forecast and estimates, so that definite warnings can be issued for the tributaries and main stream.

It has been brought to my attention that, in general, the recommendations and suggestions that I have given are very much in accord with the plan now being worked out by the Weather Bureau, whereby the bureau officials are striving for reorganization and strengthening of their river and flood service. To overcome the admitted weakness of this work, they have recently placed qualified hydrologists in two of the drainage basins and contemplate an adequate number when funds are available. They also feel that they now have sufficient discharge data to place this work on a more rational basis and have started to change over from their "rule-of-thumb" forecasts on river stages.

My suggestions is to consider in our program of flood control the reorganization and strengthening of the river and flood service of the Weather Bureau, giving undivided responsibility to the Weather Bureau, together with the means to promote the work. It does not seem logical nor desirable, in these days of government spending and experimentation, that the Weather Bureau should be handicapped by insufficient funds to make their service first-class, with adequate facilities ready for the emergencies. I am sure the funds would be efficiently administered. Not only would it result at once in worthwhile and lasting benefits to everyone, but, the impetus given to forecasting of meteorological conditions in general would lead to unforeseen benefits. Certainly, an adequate, unified flood-forecasting service should be considered in any national flood-control program, for not only would such a service limit to a great extent the justification for expensive flood-control projects undertaken because of expediency, but the proper operation of flood-control projects will be dependent upon accurate flood forecasts.

Indirect Employment from PWA More than Half of Direct Employment

FOR EVERY THOUSAND MEN employed at the site on PWA construction projects, 658 men are employed in the fabrication of the materials used on the work. This conclusion is reached in a survey made by Herman B. Byer of the Bureau of Labor Statistics and published in the October number of the *Monthly Labor Review*. The survey is a preliminary report on a study which is now nearing completion.

Mr. Byer found that in the three-year period from the start of the PWA program to June 1936, contracts had been awarded totalling $3,122,623,000 for federal and non-federal construction projects. Up to June 15, $692,928,000 had been used for payrolls at construction sites, representing 6,475,000 man-months of labor. Material orders during this same period total $1,288,775,000, producing an additional 4,261,700 man-months of labor in the finishing of material. Thus the total employment produced by the three years of the PWA program is, according to Mr. Byer, 10,737,700 man-months. These figures do not include extraction and transportation of raw materials, but only fabrication work in mills and factories.

The bureau arrived at its figure for indirect employment by attributing to PWA that fraction of a manufacturer's payroll which PWA orders are of his total production. Thus, if one-third of a manufacturer's total output goes into PWA construction, the statisticians estimate that one-third of his total payroll is attributable to PWA orders.

Typhoid Fever Outbreak Traced to Polluted Spring

IN AN OUTBREAK of 60 cases of typhoid fever in Bergen County, N. J., between July 1 and Sept. 7, it was determined, according to the *Public Health Report*, Vol. 51, No. 42, that 40 of these cases were traceable to a polluted spring in the town of Englewood. Investigation showed that the spring water was used by persons passing by, who stopped for a drink or took home bottles of the water. The spring was actually a stone reservoir fed by a pipe and having an overflow spout. The water had evidently been polluted by human feces deposited nearby, the contiguous area being covered by a growth of bushes. Numerous rodent holes permitted the surface water from heavy rains to wash this pollution down to an open jointed tile pipe that carried water from a hidden spring to the reservoir.

CURRENT HIGHWAY PROBLEMS—IX

Long-Time Road Planning

Rooted in public benefit and convenience, long-time planning includes all highways and rests on statistical investigation

By Charles B. Breed
Professor of Railway and Highway Transportation, Massachusetts Institute of Technology, Cambridge, Mass.

DOGMATIC ASSERTIONS *regarding road planning invite certain contradiction but in general it may be said that there is no budget planning of highway improvement over a period of years in the United States. Lest exceptions be hurled at us instantly let it be said that this statement does not deny a wide measure of public-roads planning. Since* 1916 *state and federal-aid system planning has been a requirement for the benefit of federal aid in roadbuilding expenditures. Similarly state aid to counties, absorption of county roads by states and of township roads by counties, and other methods of centralization have brought a measure of planning to secondary and tertiary road systems. Again individual metropolitan counties have carried out well-planned system improvement. This system planning has rarely been on a budgetary basis for a period of years and never for all roads of the states. The reasons for this situation are reviewed in the article that follows. Approaching the subject as a student of transportation, Professor Breed presents an analysis of conditions and outlines the methods that need to be followed for long-time highway planning with a budgeted system of financing.* —EDITOR.

UNTIL THE BEGINNING of the twentieth century the requirements of the horse-drawn vehicle controlled the characteristics of roads and pavements. At that time few of the states had a highway department or any other central authority for administering highway layout and construction in a state-wide sense. Road control was local; it was in the hands of the counties or townships and between these there was little cooperation. Even as late as 1910 few states had organized highway departments. A more or less coordinated system of rural highways had developed by a natural growth, influenced somewhat by commercial and governmental needs; but it was not the result of deliberate planning as a highway system. The era of growth had been one of equine transportation and had been of long duration; the best roads developed during that era were of gravel or waterbound macadam and were quite suitable for horse-drawn traffic but proved wholly inadequate for the needs of faster moving traffic.

Planning has evolved

It became apparent that just as the introduction of the locomotive had led to the development of the railroad systems, so the invention of a new and swift means of land travel, the automobile, demanded new facilities. New highway systems were essential, and local control as a method of administration was impossible. This led to the beginning of systems of rural highways and the inception of state-highway planning.

First State Action—The Federal Aid Act of 1916 required that every state must have a state highway department or its equivalent before it could avail itself of the benefit of federal funds. This act as revised in 1921 also required that a certain percentage (3 per cent) of each state's rural highways should be designated as primary or trunk-line highways and another (4 per cent) selected as important intercity and connecting roads. For these important roads, the control was centralized in one organization and for the first time a systematic plan for their improvement was made possible. The need for long-time planning was not at first apparent or pressing because the immediate needs were so obvious. The problem was to improve at once those roads which were so inadequate as to be practically impassable for motor traffic during much of the year, and to extend the improvement each year as finances permitted.

In this initial stage the secondary and local roads, outside the selected state-highway system, remained in the hands of the counties and townships. Some states provided financial aid and supervision for the construction of these local roads, but there was no centralized planning for their systematic improvement. Also each incorporated city and larger town had some sort of street department before the automobile appeared. These departments were faced with the problem of adapting their streets to motor traffic, and in general they worked out their own salvation individually without much financial or engineering aid from the state-highway department.

Extension to Local Roads—During the first two decades of the present century state-highway departments were created; in the third decade the motor truck and bus added new engineering problems. By 1930 the primary systems of state highways in many states neared completion in terms of improved surfaces on existing locations, yet many miles as initially constructed soon proved to be inadequate because of the unanticipated increase in traffic and increase in wheel loads brought about by the advent of the heavy truck. The problem of the present decade is the modernization of pavements of obsolete types, improvement in alignment for higher speeds and improvement of local roads which were forgotten in the feverish rush to improve the main routes of travel. The mileage that has been improved is but a small percentage of the total, yet the greater part of the traffic has been given fairly adequate roads. Attention is now being given to local roads serving farming districts and smaller towns, which are feeders to the state system. Many of these roads are the original dirt roads with no appreciable improvement. But the slogan "take the farmer out of the mud" has become popular and progress is being made in this field.

The improvement of these local roads with the aid of state funds is being accomplished in two ways; either a large mileage of these roads is being added to the state-highway system (as in Pennsylvania), or a larger part of the motor-vehicle revenue is being allotted to local roads with the supervision of their improvements vested in the state-highway department. This centralization of authority over the improvement of all rural roads of any importance has made possible a coordinated systematic development of the whole rural system. Here again, however, the immediate needs are so obvious that the necessity for long-time planning has not been given adequate attention.

City and Town Planning—During this progress of rural highway development the cities and towns were left pretty much to themselves. At first their problem was to convert their

cobble-stone and waterbound macadam streets into smooth and dustless thoroughfares. A few arteries through or around cities were built by the state-highway department for the purpose of expediting through traffic, but these improvements, although costly and of great service to the motoring public, still left the major burden of traffic expenditures upon the shoulders of the local city-and-town street authorities.

When a rural highway becomes congested, additional lanes or alternate routes can be provided without great cost other than for their construction. In urban districts however the land is occupied and valuable, and the cost of street widenings is often prohibitive. The traffic problem of a city must be developed scientifically by making the best possible use of the existing facilities available and by construction only of those new facilities which are definitely essential. This type of development requires the most careful planning. To this end most cities have permanent planning boards which study the highway and traffic problem of their metropolitan district as a whole, and make recommendations for its improvement both as to physical layout and traffic control.

One of the biggest fields for highway planning and future development lies in the cities. The solution of their complicated problems will tax the skill and ingenuity of engineers and planners for years to come. City surgery will solve some of the vexing problems, elevated highways others, but scientific traffic routing and control of parking will go far toward simplifying the city-planning problem.

Trend to Centralization—In recent years there has been a definite trend toward a further centralization of highway planning in a planning board or commission which shall view objectively the highway problem of an entire state without respect to classification or jurisdiction. Such a commission is usually made up of representatives from the state highway department, local county and township road authorities, municipal highway organizations, and legislative appointees. Its purpose is to develop a plan of highway improvement which will best serve the public needs both present and future, to recommend the proper allocation of motor vehicle funds for the realization of this plan and to offer a program of improvement covering a period of several years in advance.

Broader planning vital

Planning of this broader sort has long been necessary, since the independence of authority for state highways, local roads and city streets leads to an unbalanced development of the highway network as a whole. The motor-vehicle owner who has a right to expect highway service is no respecter of these arbitrary divisions. He travels freely anywhere, passing from township road to state highway and through city streets, without knowing where these boundaries are. The logical justification for highway planning and development is the highway service rendered by these public works. The extent and relative value of this service can be obtained only by traffic and economic surveys which embrace all highways. Generally speaking, the highway user is willing to pay the cost provided he receives highway service. The logical basis for the proper allocation of highway funds therefore lies in the improvement in public benefit and convenience.

In the past the tendency has been to concentrate motor vehicle revenue upon the state highway systems which comprise only about 10 per cent of the total mileage in most states and accommodate from one-third to one-half of the total state traffic measured in vehicle-miles. This disposition of motor vehicle funds was necessary at the start in order that the much-needed primary system could be built quickly to meet the rapidly increasing use of the automobile. But now that this has been accomplished to a large extent, future development and planning should take more careful note of the source of highway revenue and distribute these funds with greater attention to their source. The classification of highways which is of benefit to the highway planner is one based upon traffic use and service rendered. Such a classification must be state-wide and cannot be cramped or distorted by political or administrative boundaries. The carrying out of a highway plan may be entrusted to the several highway administrative authorities but the conception of the plan and the recommendations for its execution schedule should come from a planning body which has possession of all the facts and interprets them impartially.

Failure to plan broadly and farsightedly has led to an unfortunate diversion of motor vehicle funds in many states. With the completion of the primary system all motor vehicle funds were not immediately required for that system in many states. Many legislators have come to believe that this created a source of easily-collected revenue which could be devoted to other purposes and large amounts have been appropriated for purposes other than highways. Once diverted, these funds are recaptured only with difficulty. Had there been sound long-time planning based on a comprehensive study of all highways, it would have been possible in most states to demonstrate that all available motor-vehicle funds, and more, were required for the necessary development of local roads, for the continuous maintenance and modernization of the primary system and for the relief of traffic congestion in urban centers. The time is at hand when a stabilized program of statewide highway development and maintenance should be prepared by every state in the Union and an estimate prepared of the financial requirements for that program over a period of years. This would be the sound and logical answer to the diversion of highway revenues.

With this end in view, commissions have recently been appointed in a number of states, notably New York, Michigan and Illinois. These bodies are engaged in assembling the necessary traffic and economic data. The state of New York recently reported a five-year program for highway improvement based upon the results of a comprehensive state-wide survey.

Highway planning should be regional in character and not limited even by state boundaries. There should be cooperation between states, so that the best interests of the region as a whole may be served. In New England, for example, a regional planning commission has been created, which is working out a plan for this region in cooperation with the several state planning boards and other interests. The activities of this planning commission include consideration, not of highways alone, but of all other modes of transportation; they include also consideration of resources, flood control, industry and recreational facilities, all of which are regional in character.

Basic data required

One of the first steps in long-time highway planning is to evaluate present highway facilities both as to their physical condition and their traffic use. With regard to the state systems, much of this information is available from the records of the highway departments, but is not assembled in such a way as to be readily available for planning purposes. Many states keep dependable records of the character and costs of their highway work, but these are usually buried in the files according to the many contracts under which work was done, and in their present state reflect no adequate picture of the system as a whole. Such data should be assembled according to road type and location, so that the cost and construction history of each route can be traced continuously from start to completion. Information of this kind can be comprehended more easily if plotted upon a large-scale map of the highway system. A map of this sort is often referred to as a "master map" and is the foundation of highway planning.

The master map will not necessarily be a single map but a series of maps with the same road map skeleton, each map showing a different set of data. One map, for example, should show the physical layout, such as width, type of surface, year of construction and limits of contracts. Another map should show traffic data classified according to passenger car traffic, truck and bus

traffic. This should be represented in a variety of ways: as average annual traffic, average daily traffic, daily traffic as of a given month and maximum daily traffic. A further subdivision of the traffic by origin and destination should be made for purpose of determining at a glance the division of the traffic stream on any road between through traffic and local traffic. Another map should show the economic characteristics of the highway system with respect to such items as construction cost, maintenance costs, all developed into annual costs. Additional maps should be prepared showing the accident history of the highway system, speed characteristics, population trends, wealth distribution, industrial and rural areas and other data pertinent to highway planning.

The final master map should be one showing the adopted classification of all highways, and the proposed plan for improvement, with a schedule of procedure in carrying out the plan. This is the practical process of long-time planning.

As stated above, the necessary statistical data for plotting these basic maps are usually available in the highway departments and often centralized at the main office where it may be obtained by sufficient digging in the files. Such work requires a large force of men and is a fertile field for works-relief projects for the "white collar" unemployed. It may also be carried on by the regular state forces in the winter months when construction work is at a minimum. Traffic data are available over a period of years in many states. These have been extended greatly in recent years by relief projects devoted to traffic counts and analysis. Massachusetts, for example, has made periodic traffic counts on state highways since 1909 and is now engaged in counting traffic on all rural local roads. Traffic surveys for origin and destination for the purpose of distinguishing between through and local traffic have been made in a few states, but for most states this represents work still to be done.

The extension of the master maps to include data on all rural roads and town and village streets is not easily accomplished. Where records for these do exist, they will be found scattered throughout the files of many different organizations, but there is so little uniformity between methods of accounting that the data obtained from different sources may not be comparable. A more satisfactory way of assembling data for these highways is to take an inventory of them in the field. This can be done by examination of the entire mileage of these roads, making note of the physical condition and general character of the traffic which use these roads. The thoroughness of the inventory should be varied according to the importance of the road.

From the data assembled on the master plans, it is possible to make a classification of all highways according to their traffic importance, starting with the most-traveled primary roads and ending with the local land-service roads serving only the farms in rural areas. A further subdivision may be made of the primary system into roads that are largely commercial and those which are used largely by private passenger cars. The classification should be flexible and changed from time to time as roads are improved or traffic importance is increased.

A comparison of the master maps of highway condition and traffic importance will reveal how well any present degree of development fits traffic needs. It will identify those roads that are inadequate and require immediate attention; and it will also bring to light other undeveloped connecting links which would be of traffic importance if properly improved. From the classification and condition maps a schedule of progressive improvement may be prepared, which will be the basis for a stabilized highway program for the years ahead.

Anticipating the future

The data obtained from planning surveys and available on the master plans should be studied intensively to find out how well highways of types now in use have served and are now serving their traffic. This should be done in order to prevent repetition of the mistakes of the past and to provide more serviceable highways in the future. The proper selection of surface type and of width and alignment has been given too little thought in the past. This selection has social and economic aspects which are as important as the engineering features. Future road improvements should be designed to give adequate facilities safely and at a minimum annual cost.

In the past too many highways have been constructed from rigid standards prepared from engineering considerations alone and used widely without consideration for varying traffic demands. This has resulted in overdesign in some places and underdesign in others. As traffic demands vary widely over different parts of a highway system so should types of pavements vary.

The past history of roads in service should be examined to see how well they have served their traffic, both as to adequacy and economy. This involves a study of their traffic density, maintenance costs of all kinds, probable service life, riding and safety qualities of the surface and state of congestion. All these data should be available from the planning surveys and used to the utmost in planning future highways at the least cost and the greatest service to the public. A multitude of types of pavement have been developed, varying from high cost to low cost. The choice among these should be based on the facts discovered by a study of similar roads in service. The design of alignment, width, and grades should likewise be based upon past experience, supplemented with a study of trends in motor vehicle use, accident occurrence and developments in motor vehicle design. Roads in service should be studied from the point of view of safety. Which highways have the poorest records, which the best records, and why?

Highways should also be designed with due regard to the present and probable future demands of the region served. Will the growth be industrial, residential or rural? Is the population and motor car use increasing or decreasing and at what rate? A wealth of traffic data has been assembled in many states showing the changes which take place in traffic volume after the improvement of highways or the building of alternate and bypass routes. These should be studied and used as a guide in predicting future traffic growth. For example, Massachusetts periodically prepared an increase and decrease traffic-flow sheet showing graphically the changes in traffic flow which follow the progressive extension and improvement of the highway system and also the changes which result from local conditions such as the closing of a mill or development of a new recreational center.

Closely allied with anticipated future requirements is a question of the future limitations of weight and size of motor vehicles. If limitations remain as they are now and no further weight increases are allowed, the highway problem in many states will develop into one of maintenance of existing improved highway facilities, with occasional extentions and widenings to take care of increased volume of traffic. Further regulation may be necessary to limit the loads allowed on improved secondary roads which cannot be built economically and at the same time serve the heavier vehicles. A logically developed long-time plan for highway improvement must be corelated and supported by intelligent legislation relative to vehicle loads, so that the present system of highways may be protected against loads heavier than those for which they were designed.

Financing the highway plan

Once the highway has been set up and the priority of projects established, the next step is to allot the available funds to these projects. The available funds will in general be the motor vehicle taxes, and the amount of work which can be done in each year will be limited by the amount of these funds. For certain large projects, such as long span bridges or the municipal arteries, it may be advisable to raise funds by bonds which should be amortized from motor vehicle revenue.

The apportionment of funds should be made according to the needs of the

plan and with appropriate attention to the source of motor vehicle revenue. The apportionment cannot be limited to any one system of highways but must be general, embracing state highways, local roads and city streets. In order to accomplish such a distribution new legislation may be needed in some states. The present practice of rigid distribution between state highways and county roads and the diversion of highway revenue to other purposes must be corrected. In many states the disposition of motor vehicle funds varies greatly from year to year, depending upon the whim of the legislature, much to the detriment of progressive highway development. Legislation for the carrying out of a highway plan must be for a period, preferably not less than five to eight years. In this way the consummation of a substantial portion of the plan will be possible and highway development in general will be on a stabilized basis for this period.

Motor vehicles pay gasoline taxes and registration fees. Gasoline taxes are in effect a service or vehicle-mile tax. These taxes on a vehicle-mile basis represents the toll which these vehicles are paying to the state for the privilege of driving on the highways. The product of this vehicle-mile tax contribution and the number of vehicle-miles traveled on a given road is equal to the earnings of that road. Every road that is traveled contributes something toward the total tax collected in the state. The lightly-traveled roads contribute little, the more heavily-traveled roads, much. This revenue accrues from every traveled way in the state, and every road in the state is entitled to a share in it. The distribution of funds cannot be made to each road individually, but the distribution as between classes or systems of highways should bear some relation to the use made of them. This distribution should be based on complete traffic data. As time goes on these data are becoming more and more complete.

Michigan recently completed a traffic survey which showed that about one-half the vehicle-miles traveled in the state were on city streets, about one-third on the state highway system and the remaining one-sixth on local roads. The logical ultimate disposition of motor vehicle funds must be decided on the basis of such data. The automobile is essentially mobile, its place of garaging is no evidence of the roads used. The composition of traffic as to origin and destination is of economic interest, but so far as the traffic service which a road must provide is concerned, it matters little whether a vehicle came from an adjacent farm or 200 miles away.

While the highway system as a whole is still in its state of initial development, it may not be practicable to allocate funds wholly on a traffic-use basis. The needs of one unit of the system may be so great that it is advisable to devote a larger share of funds to that system than to another of greater traffic importance but less-urgent needs. Ultimately, as all branches of the system reach a state of development appropriate to their needs, the highway problem will be one of maintenance and reconstruction and the allocation of funds should more nearly approach a direct proportion to source of revenue as indicated by road use.

Long-time planning of highway improvements and maintenance is as logical a procedure in the interest of the public as it is in any large business enterprise. That the public is beginning to awake to this fact is encouraging. In its intelligent conception lies economy, safety and the evident answer to diversion of highway revenues.

Mountain Dam Spillway Housed for Winter Work

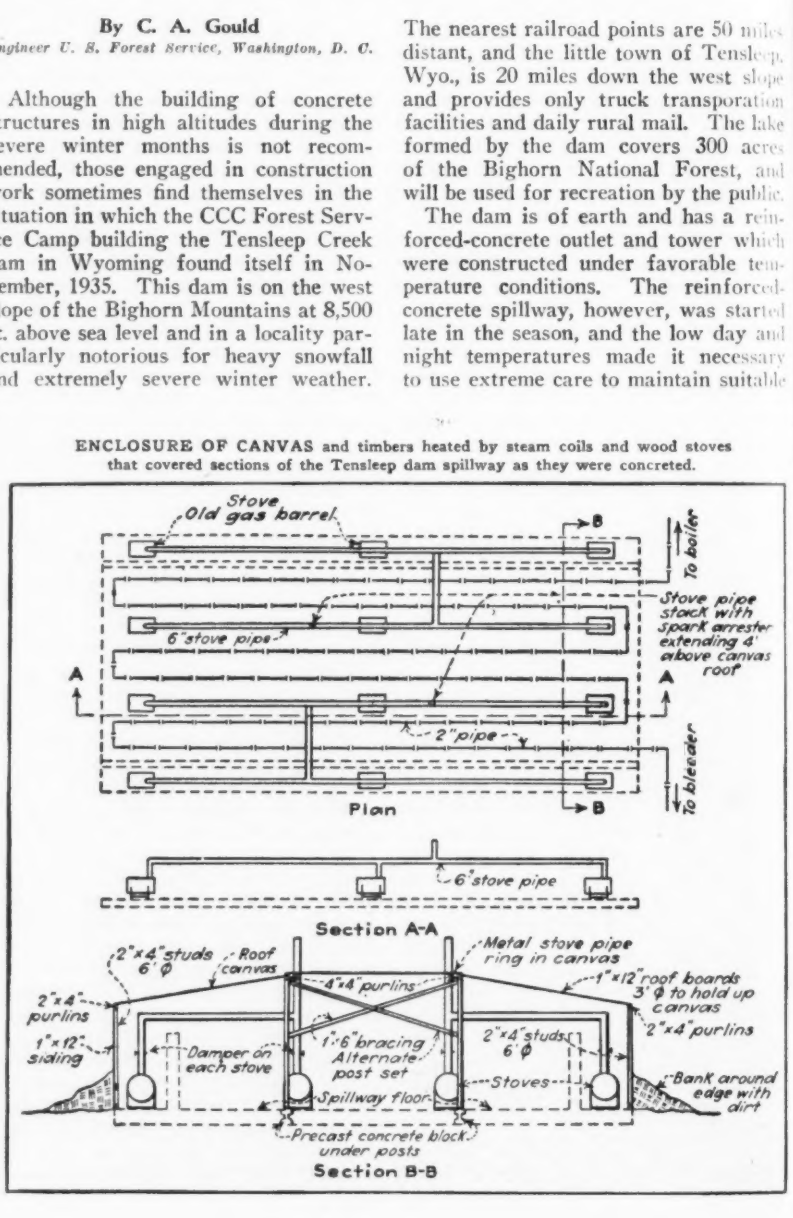
Concrete placed under a frame and canvas house heated by steam coils and wood stoves job-built from camp material

By C. A. Gould
Engineer U. S. Forest Service, Washington, D. C.

Although the building of concrete structures in high altitudes during the severe winter months is not recommended, those engaged in construction work sometimes find themselves in the situation in which the CCC Forest Service Camp building the Tensleep Creek dam in Wyoming found itself in November, 1935. This dam is on the west slope of the Bighorn Mountains at 8,500 ft. above sea level and in a locality particularly notorious for heavy snowfall and extremely severe winter weather. The nearest railroad points are 50 miles distant, and the little town of Tensleep, Wyo., is 20 miles down the west slope and provides only truck transporation facilities and daily rural mail. The lake formed by the dam covers 300 acres of the Bighorn National Forest, and will be used for recreation by the public.

The dam is of earth and has a reinforced-concrete outlet and tower which were constructed under favorable temperature conditions. The reinforced-concrete spillway, however, was started late in the season, and the low day and night temperatures made it necessary to use extreme care to maintain suitable

ENCLOSURE OF CANVAS and timbers heated by steam coils and wood stoves that covered sections of the Tensleep dam spillway as they were concreted.



conditions under which the concrete could be mixed, placed and properly cured. Temperatures as low as 32 deg. below zero prevailed at times but only for short durations; the average temperature during construction was from 0 to 10 deg.

The spillway was concreted under a housing made by supporting old canvas and available tentage over a framework of lumber; a cross-section is shown by the accompanying sketch. The canvas was stretched over this framework from cut-bank to cut-bank of the spillway excavation, and no cold air was permitted to enter except as workers passed through canvas flaps which hung over the openings.

Beginning with the mixing process, heat was provided for both the mixing water and the aggregate, and the mixing plant and aggregate pile were housed under canvas supported on framework similar to that used for the spillway. The water was pumped from the river to a 3,000-gal. galvanized-iron tank about 60 ft. above the river and above all concrete operations. Heat was supplied to the water by a 12-hp. coal-burning vertical boiler from which a 1-in. pipe conducted the steam through an open end at the bottom of the tank. This kept the water in the tank hot and in its travel to the mixer very little heat was dissipated as the supply pipe ran under canvas for most of the distance. The piles of aggregate were heated by two furnaces of two 24-ft. lengths of 24-in. corrugated-metal culvert pipe; the pipes were placed on a slight grade on the ground near the loading hopper of the mixer and were fired with wood at the lower end. The upper ends of the pipes extended outside the canvas house, thus conducting the smoke away from the workers. The aggregate was hauled from the gravel pit by 1½-yd. dump trucks and dumped on top of the 24-in. pipes, keeping a sufficient quantity piled over the furnace to supply aggregate for a section, or pour, of the spillway. The concrete was chuted from the mixer to wheelbarrows and transported to the forms along scaffolds placed on a level with the tops of the forms and reached the forms at a temperature of about 80 deg.

Heat was provided inside the spillway house both by steam coils and wood-burning stoves. The steam coils were built up from scrap pipe, 2 in. in diameter, placed in parallel lines, spaced 4 ft. apart for the full length, the lines being connected into a continuous line as shown by the drawing. Live steam, in a small jet, was allowed to escape inside the canvas shelter, when men were not working inside, and the end of the steam line was equipped with a valve for a bleeder which was opened slightly to prevent freezing in the line.

The wood stoves were made from old metal gasoline drums. The drums were horizontal. These stoves were built and arranged to give uniform heat throughout the section of concrete being protected, using an average of 12 stoves to each section. The gasoline-barrel type stoves, as constructed, made a very satisfactory heating device and one 6-in. pipe flue served to carry the smoke from six stoves and provide sufficient draft to keep the fires alive.

Heat was provided around each section of concrete for 72 hours after it was poured, and field tests indicate that a good quality of concrete was obtained. A 5-kw. electric-light plant was set up at the upper end of the spillway from which distribution lines were run through the canvas house over the spillway and to other points around the dam where light was required. The light made possible the placing of reinforcing steel and forms at night. After the spillway concrete was placed, the canvas was stretched on framework over the cut-bank slope, making it possible to backfill and tamp earth on the outside of the spillway walls under favorable conditions.

The cold weather made it impossible to dress up the dirt and rock slopes around the spillway, but it was considered that a satisfactory job had been accomplished from the standpoint of safety and use, leaving the landscaping and finishing touches to be done during the following summer season.

Bridging the Rio Chiriqui On the Pan-American Highway

Panama structure, first of three in Central America, is a 400-ft. span cable suspension bridge with unloaded backstays

By Conde B. McCullough
U. S. Bureau of Public Roads, San José, Costa Rica

THE FIRST OF THREE bridges, (authorized in a preliminary program of bridge building on the Inter-American Highway in Central America) to be placed under construction crosses the Rio Chiriqui in the Republic of Panama. Together with bridges over the Choluteca River in Honduras and the Tamasulapa River in Guatemala, it is being financed by an appropriation made in June, 1934, by the Congress of the United States. The work is being done by the U. S. Bureau of Public Roads. Central American cooperation consists in financing and constructing the substructures of the bridges.

In Panama, the Carretera Inter-Americana traverses the country entirely on the Pacific slope, crossing Balboa basin on a ferry and passing through the towns of Penonomé Aguadulce, Santiago, Soná, Remedios, David and Concepción before reaching the Costa Rican frontier. The Chiriqui River bridge is located some six miles east of David.

Selection of type

The design type selected is a 400-ft. cable suspension span with unloaded backstays. The sag ratio is 1 : 10, the clear roadway width 20 ft. and the total out to out length 655 ft. This type was chosen after rather mature and detailed study for the following reasons:

(a) It is the only feasible type which lends itself to construction without falsework. This was probably the controlling factor in the selection. The so-called *invierno* (winter, or wet season) in Panama extends from May to December inclusive. The rainfall during this period varies in different locations from 60 in. to as high as 200 in. Rainfall is generally intermittent, but there are frequent periods of exceedingly heavy rain which continue for several days. This concentration of rainfall coupled with the character of the drainage area renders Rio Chiriqui a difficult stream for falsework. Rapid rises accompanied by reported current velocities as high as 12 to 15 m.p.h. occur during the wet season, and even during the month of February (which is probably the dryest month in the year) the records indicate the possibility of sudden minor floods with flash run-offs and high current velocities on the flood crest. Under conditions such as these the difficulties inherent in the maintenance of falsework become almost unsurmountable, especially with a stream bottom consisting of solid rock overlaid with a shallow stratum of gravel, which precludes the possibility of driving falsework piling.

(b) It is the only type which transmits its load through a flexible elastic tension system. This fact renders it particularly resistent to stresses caused by seismic movements.

(c) Compared with other types, the center of gravity of the suspension span is located well below the level of its supports (tower saddles). This fact

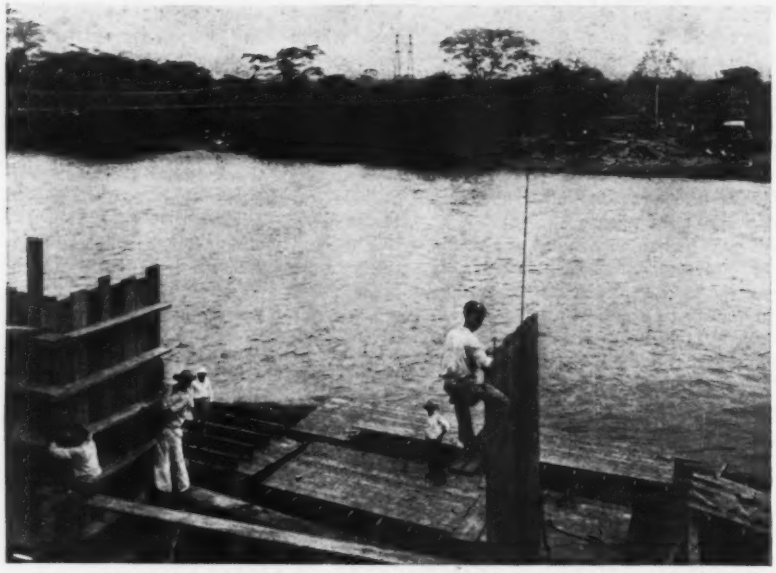


FIG. 1—SITE of the Rio Chiriqui Bridge. Form erection for the west pier is under way in the foreground. Across the river the foundation for the east pier is being excavated. The old suspension bridge, to be replaced by the new structure, is shown upstream.

FIG. 2—WEST PIER of Rio Chiriqui Bridge, complete on October 4. In the background are the construction plant buildings.

also operates greatly to reduce earthquake hazards and to cut down wind-stress values.

(d) Because of the elimination of falsework, the suspension type lends itself in Central America to superstructure construction at any season of the year, thus rendering it possible to formulate an uninterrupted project program.

(e) The heavy mass-concrete anchorages necessary with this type lend themselves to construction with a minimum of skilled and a maximum of unskilled labor, thus taking advantage of a comparatively cheap labor market and making it possible to provide a maximum in local employment.

(f) The character of the natural foundation material (solid rock) is such as to render the construction of piers on the stream banks rapid, cheap and easy. A channel pier, on the other hand, would have been extremely expensive, because the shallow gravel overburden coupled with the swift currents encountered would have necessitated a heavy double-wall puddle cofferdam.

The only alternate was a cantilever with short counterweighted anchor arms, and this was discarded because of expense and unsightly appearance.

Details of design

All footings are founded on solid rock except the north pedestal, which rests upon a coarse gravel stratum. The abutments are of the so-called U-pedestal type, being in reality girder approach spans with enclosing curtain walls. The anchorages are of cellular construction. Other details are as indicated on the accompanying drawing.

The stiffening truss system is of a conventional type, hinged at the towers. An attempt has been made to avoid the use of lace bars and battens; the chords are of the U-type and the diagonal system of rolled and built up I-sections. Curved gussets for architectural effect are employed for the top chord.

In the tower design considerable attention has been paid to architectural detail. Box sections have been employed whenever possible; the inspection openings in the main tower columns have been given an arched top outline, and the portal and top strut have each been proportioned to the form of an ogival or pointed arch.

Sidewalks for horses

One feature of the design worthy of mention is the provision for equestrian as well as pedestrian traffic on ample sidewalks placed outside the trusses. The highways of Central America throng with horsemen, and with the inevitable future increase in motor vehicles a separate provision for this type of traffic is a most necessary safety measure. As a special concession to the horse the concrete sidewalks have been covered with asphalt planking over a width of five feet.

The cable consists of nineteen galvanized, prestressed bridge strands, six of 1⅛-in. and thirteen of 1½-in. diameter. Each strand is to be cut and measured to exact length, and end sockets are to be attached in the shops. The locations of center lines of towers and cable clamps are to be marked on the cables for erection purposes. In order to prevent concentrated loads on the individual wires and to prevent a tendency to unwind the strands, adjacent strands of the composite cable are specified to be of opposite lay. The modulus of elasticity of the strand ropes after prestressing is specified to be not less than 24,000,000 lb. per sq. in. and the yield point not less than 75 per cent of the ultimate strength. The specifications have been so worded as to allow the fabricator, if he so desires, to submit for approval alternate cable designs employing twisted wire rope in lieu of the bridge strand rope specified.

After all dead load is on the span and the necessary adjustments made, the cables are to be packed with suitable fillers and given a heavy coating of thick red lead paste followed by a wrapping with No. 9 soft annealed double-galvanized wire. The various cable strands are splayed at the anchorages.

Design loads and stresses

Stringers and floorbeams are to be of silicon steel and all other members of carbon steel. The loading employed was standard H-15. The basic unit working stresses in tension are 18,000 lb. per sq. in. for carbon steel and 25,000 lb. for silicon steel. These stresses were increased 25 per cent for the following conditions of loading:

(a) Dead load plus live load plus impact plus temperature; (b) Dead load plus half live load, plus impact, plus temperature, plus wind. For the stiffening trusses, an additional 10 per cent increase in working stress values was allowed, this procedure being in accordance with usual practice which permits a higher working stress for stiffening truss members on the theory that the integrity of the structure is not dependent thereon. The towers were

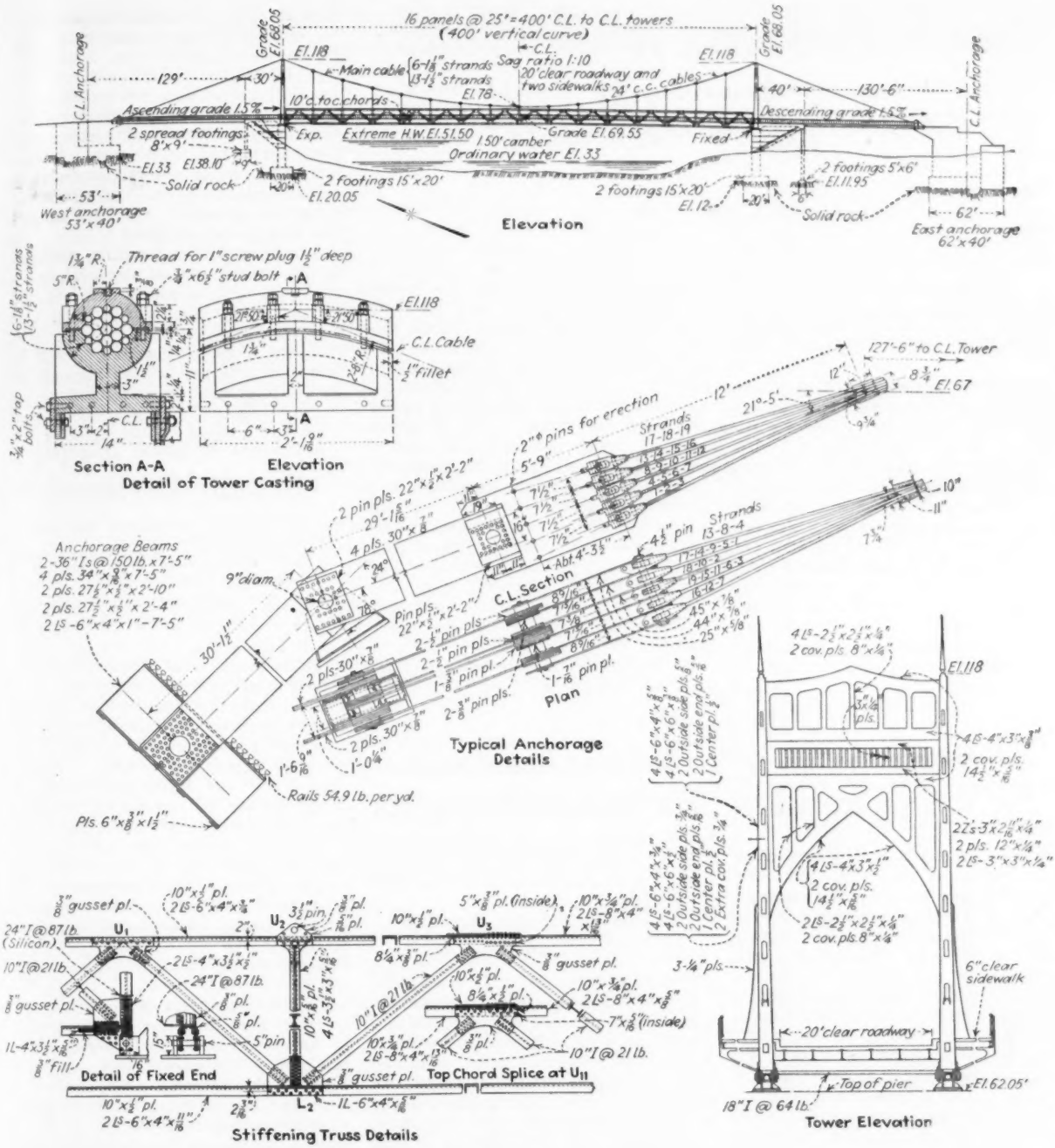


Fig. 3—STRUCTURAL details of Rio Chiriqui Bridge on the Pan-American Highway in Panama

designed for a horizontal earthquake loading equal to 10 per cent of the gravity loading.

One connection in each of the chords is to be left open at or near each of the quarter points until the span is under full dead load to eliminate all dead load stress in the stiffening truss system. All structural steel work is to be given one shop coat of red lead and oil paint except for the inside portions of box sections which are to be given four coats of red lead and oil paint in the shops. In the field all structural steel and castings as well as the cable system are to be given three additional paint coats.

The work is being done (cooperatively with the various interested republics) by the U. S. Bureau of Public Roads under the general direction of Thos. H. MacDonald, chief of the bureau and under the immediate direction of E. W. James, chief of the division of highway transport. D. Tucker Brown is in charge of all operations in Central America, and the writer has been temporarily assigned to his organization to supervise the design and construction of these bridges. Raymond Archibald is first assistant bridge engineer.

The U. S. Steel Products Co., New York has the contract for the superstructure which will be fabricated and erected by the American Bridge Co. The substructure was built on a day labor basis by the Republic of Panamá, under the direction of Sr. Don Tomás Guardia, Ingeniero Jefe de Caminos.

Book Reviews and Notes

A Monthly Commentary on Current Additions to the Civil Engineer's Library

Bridges Old and New

THE STORY OF BRIDGES—By Archibald Black. Cloth; 6 x 9 in.; pp. 226; halftones. Published by Whittlesey House, New York. Price $2.50.

Planned to interest and instruct the lay reader, this book, written by an engineer who is a special writer for the Port of New York Authority, has proper value for the engineer and particularly if he is not a bridge specialist. The outline followed is historical from the Roman aqueducts through the age of timber and iron to the modern era of steel and reinforced concrete. An innovation for this type of book is chapters devoted to the problems of the foundation builders, the designers and the erectors. The book contains 66 illustrations showing interesting and famous bridges.

Commercial Alloys

ENGINEERING ALLOYS—By Norman E. Woldman and Albert J. Dornblatt. Fabricoid; 6 x 9 in.; pp. 662; tables. Published by American Society for Metals.

AN ELABORATE but confusingly arranged list of proprietary alloy steels and other alloys, followed by a list of manufacturers, an advertising section and a slender collection of "useful data" tables, forms the odd book that has been put together under the title of "Engineering Alloys." The situation that led to the laborious compilation is sufficiently indicated by the fact that more than 8,000 alloys are listed—most of them with chemical composition in at least approximate form, and a considerable number with strength figures and a brief statement of leading qualities. The book may enable alloy steel users to find some desired data not otherwise within reach.

Power Development History

NEL CINQUANTENARIO DELLA SOCIETA EDISON—1884–1934—By various authors; Cloth, 9 x 13 in.; total pages 1,947; halftones and line drawings. Published by Societa Edison, Milan, Italy.

THE SOCIETÀ EDISON of Italy for its fiftieth anniversary undertook a monumental task; it set out to trace the history of the technical and economical development of the electric power industry of the whole world, a record that has been written largely in the life span of the Società Edison. The results of its vast undertaking are found in four large and beautifully printed volumes of which any organization may justly be proud. Two of the volumes are so well and profusely illustrated that even those who do not read Italian can learn much from the line drawings and half tones. Volume I is devoted to the evolution of hydraulic structures, prime movers, electric machinery and transmission lines. Vol. II is devoted in part to the general ecenomic problems of the electric industry and in part to the special problems of Italy. The latter subject is continued in Vol. III. Vol. IV is devoted to the development of Milan, where the Societa was found, and to the company's own history. The first and last volumes are those that are illustrated.

German Handbook For Sanitary Engineers

TASCHENBUCK DER STADTENTWASSERUNG—By Karl Imhoff. Paper; 4½ x 7 in.; pp. 195; tables and diagrams. Published by R. Oldenbourg, Munich and Berlin. Price 5.40 R.M.

Reviewed by WILLEM RUDOLFS
Chief, N. J. Sewage Experiment Station, New Brunswick, N. J.

THIS little handbook of convenient format has become more and more a guide for engineers, interested and engaged in the construction of sewerage systems and sewage treatment plant design, who do not require extensive detailed information. The engineer finds in the book an array of reference material needed for the solution of his problems. Complicated formula and time-consuming calculations have been avoided whenever possible. This new edition has been completely revised and considerably enlarged. The section dealing with self-purification of streams has been expanded and some more definite conclusions given. Calculations dealing with rainwater runoff have been placed on a more general basis.

The book is divided into two parts, namely sewerage and sewage treatment. The first part deals with sewers, volumes of rain water and sewage, determination of cross sections, mains and laterals. The second section is devoted to calculation of capacities for different types of treatment as well as to some fundamental facts concerning treatment and disinfection. New chapters have been added dealing with chemical coagulation, sewage filtration, temporary treatment devices, and sludge dewatering by means of presses, vacuum filters and centrifuges. A considerable number of type examples of calculations are given. The number of references given in previous editions has been greatly reduced.

The amount of information available in this compact pocket size book is remarkable. Only constant additions and revision can produce such results. The book warrants wide circulation and, like one of its predecessors, should be translated into the English language to do the most good in this country.

British Water Supply Broadly Reviewed

WATER SUPPLY IN GREAT BRITAIN—By R. C. S. Walker. Cloth; 6 x 9 in.; pp. 244; halftones, linecuts and maps in color, tables. Published by Ivor Nicholson & Watson, Ltd., London. Price 1.11.6.

COMMISSIONED to undertake a description of water supply in Great britain that was "not too technical," the author of this volume succeeded in preparing an easily read text that is highly informative and comprehensive in scope. This is accomplished by confining discussion to broad principles and facts, the avoidance of laborious details and non-essentials, and a happy facility for presenting the subject in a lively, narrative style.

The book resolves into three general sections comprising (1) basic data on rainfall, geology and water quality, (2) schemes of water supply with chapters on impounding, underground and river resources, and (3) legislative practices and engineering facts concerning water supply.

The second section of the book, and on which the author lays greatest stress, is arranged as a summarized compendium of the water supply schemes used by the principal cities and districts in Great Britain. Excellent maps showing underground water level in various sections of the country are included as supplementary material. Of particular interest is a chapter on legislation which traces the origin and growth of water undertakings, and the development of laws pertaining to their control. Present-day problems—the extension of distribution systems in rural areas, and the conservation of water supply during periods of drought—are also discussed.

Engineers and students who seek to obtain a comprehensive picture of British water supply development will find Mr. Walker's excellent treatise worth reading; it also has merit as a source book of factual data conveniently indexed.

Miscellaneous Notes on Booklets and Reprints

WATER POWERS OF THE FRAZER RIVER in British Columbia are described in a pamphlet published by the Provincial Department of Lands, Victoria, B. C.

WORK RELIEF IN THE STATE OF NEW YORK: A review of its characteristics, functioning and value. Published by the Governor's Commission on Unemployment Relief, 79 Madison Ave., New York City.

RAIL FISSURE STUDIES being made at the University of Illinois are the subject of "Second Progress Report of the Joint Investigation of Fissures in Railroad Rails," Reprint No. 8, Engineering Experimental Station, University of Illinois, Urbana, Ill. Price, 15c.

SURFACE WATER SUPPLIES OF NEW JERSEY is the title of special report No. 5 published by the State Water Policy Commission, 28 West State St., Trenton, N. J. The report contains stream flow records throughout the state and represents investigational work for the six year period ending Sept. 30, 1934.

DATA FOR THE DESIGN of open web steel joists is provided in the 36 page pamphlet, "Steel Joist Construction," published by the Steel Joist Institute, 201 North Wells St., Chicago, Ill. Included are specifications and a code of practice for construction of steel joist floors, safe load tables, and the properties of sections manufactured by members of the Institute.

RESEARCH IN COLLEGE AND COMMERCIAL LABORATORIES is the subject of two recent publications: Miscellaneous Publication M-125 of the National Bureau of Standards (price 15c., Superintendent of Documents), covering commercial testing and college research laboratories; and "Current Hydraulic Laboratory Research, Bulletin IV-2," also published by the National Bureau of Standards in mimeographed form.

THE STORY OF THE FABRICATION and erection of the San Francisco-Oakland Bay Bridge is told in a profusely illustrated 85-page booklet just published by the United States Steel Corp. Written by the engineers of the American Bridge Co., the story is told in a straightforward technical manner that will appeal to the engineering reader. Price $1 from American Bridge Co., Frick Building, Pittsburgh, Pa.

TABLES OF SAFE LOADS for use in the design of concrete joist floors are given in a 28 page booklet published, entitled "Concrete Joist Construction" by the Concrete Reinforcing Steel Institute, 201 North Wells St., Chicago, Ill. The tables are given for both 20 in. and 30 in. wide forms in depths ranging from 6 in. to 14 in. From the tables, the depth of floor and the number and size of reinforcing bars can readily be found for any desired loading. Specifications for concrete joist floors, for 3,000 lb. concrete, for reinforcing steel, and for metal lath ceiling construction are also given.

THE ECONOMY OF THE YAKIMA VALLEY has been studied as an example of the effect of federal reclamation projects by the Washington State Planning Council. The results of this study are embodied in a 118 page report entitled "Reclamation, A Sound National Policy." The thesis of the report is that "the greater portion of this wealth [produced by irrigation] flows year after year to the centers of commerce and industry in the eastern United States."

RATES FOR ELECTRIC SERVICE to commercial and industrial consumers; comparative rates of publicly and privately owned electric utilities; and rural electric service, monthly bills, rural line construction, costs and practices; have been published as Rate Series No. 4, No. 5, and No. 5 of the Federal Power Commission as part of its electric rate survey. For sale by the Superintendent of Documents, Washington, D. C. Price, 50 cents, 15 cents, and 25 cents, respectively.

New Books and Revised Editions

[Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.]

WATER PURIFICATION CONTROL—Second Edition—By Edward S. Hopkins. Cloth; 5½x9 in.; pp. 184; photographs, linecuts, tables. Published by the Williams & Wilkins Co., Baltimore. Price $1.75.

STUTZMAUERN GRUNDBAU: Vierter Band (Lieferung 4)—By O. Mund and O. Colberg. Paper: 7x11 in.; pp. 96; photographs and linecuts. Published by Wilhelm Ernst & Sohn, Berlin. Price RM 4.95.

TASCHENBUCH DER STADT-ENTWASSERUNG—By K. Imhoff. Paper; 4½x7 in.; pp. 195; tables and diagrams. Published by R. Oldenbourg, Munich and Berlin.

TEXAS ALMANAC AND STATE INDUSTRIAL GUIDE SINCE 1857—Texas Centennial Edition. Paper; 6x8 in.; pp. 512; photographs, diagrams, tables, maps. Published by the Dallas News, Dallas, Tex. Price 50¢; 65¢ postpaid.

THE PORTS ON THE UPPER HUDSON RIVER—Port Series No. 25—1936. Prepared by the Board of Engineers for Rivers and Harbors, War Department. Paper; 6 x 9 in.; pp. 168; halftones, linecuts, tables, maps. For sale by Superintendent of Documents, Washington, D. C. Price 50¢.

CONVENTION PROCEEDINGS, AMERICAN ROAD BUILDERS' ASSOCIATION, 1935–1936—32nd and 33rd Annual Conventions. Edited by Charles M. Upham, Ethel A. Birchland and D. R. Lamson. Fabricoid; 6 x 9 in.; pp. 992; halftones, linecuts, maps, tables. Published by the American Road Builders' Association, Washington, D. C. Price $10.00.

AMERICAN PLANNING AND CIVIC ANNUAL—1936—Edited by Harlean James. Cloth; 6 x 9 in.; pp. 170; halftones, linecuts, tables. Published by American Planning and Civic Association, Washington, D. C.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE — 4th edition. Prepared by the Lincoln Electric Co. Fabricoid; 5½ x 9 in.; pp. 819; Halftones, linecuts, tables. Published by the Lincoln Electric Co., Cleveland, Ohio. Price $1.50 in U. S.; $2.00 elsewhere.

THE UNIVERSAL FORMULA OF THE ELASTIC LINE OF THE BEAM—By John Podolsky. Paper; 5 x 8 in.; pp. 152; linecuts, tables. Published in Russian by the United Scientific and Technical Publishing House of the People's Commissariat of Heavy Industry of the USSR, Moscow, Russia.

SAMMLUNG GOSCHEN HALLENBAUTEN—By Carl Kersten. Cloth; 4 x 6 in.; pp. 126; halftones, linecuts. Published by Walter de Gruyter & Co., Berlin and Leipzig.

BEITRAG ZUR BERECHNUNG VON MASTFUNDAMENTEN—By H. Frolich. Paper; 7 x 9½ in.; pp. 81; halftones, linecuts, tables. Published by Wilhelm Ernst & Sohn, Berlin. Price 7.50 RM.

DER REBHANNSCHE SATZ—By Otto Mund. Paper; pp. 34; 7 x 9½ in.; linecuts, tables. Published by Wilhelm Ernst & Sohn, Berlin. Price 2.25 RM.

WIND-PRESSURE DISTRIBUTION ON SHARP-EDGED BODIES (A continuation of the Nokkentved experiments, with reference to the influence of the thickness of the boundary layer on the wind pressure at certain points—By Harold MacT. Sylvester. Paper; 7 x 10 in.; pp. 16; halftones, linecuts. Published in Copenhagen, Denmark.

ROAD CURVES FOR SAFE MODERN TRAFFIC—By F. G. Royal-Dawson. Fabricoid; 5 x 7 in.; pp. 246; linecuts, tables. Published by E. & F. N. Spon, Ltd., London. Price 8/6 net. Engineers Book Shop, 168 E. 46th St., New York. (Price about $3.50).

CREDIT MANUAL OF COMMERCIAL LAWS—1937—Prepared by the National Association of Credit Men. Cloth; 5½ x 9 in.; pp. 572; tables. Published by the Association. Price $5.00.

STAHLBAU–KALENDER 1937—Cloth; 4½ x 6½ in.; pp. 495; halftones, linecuts, tables. Published by Wilhelm Ernst & Sohn, Berlin. Price RM 3.

ANALYSIS OF WATER AND SEWAGE—By Frank R. Theroux, Edward F. Eldridge and W. LeRoy Mallman. Cloth; 5½ x 8 in.; pp. 228; tables. Published by McGraw-Hill Book Co., New York, N. Y. Price $2.50.

PROCEEDINGS OF THE CONFERENCE ON LOW COST HOUSING—Held at Pennsylvania State College April 16 and 17, 1936. School of Engineering Technical Bulletin No. 23. Paper; 6 x 9 in.; pp. 103; linecuts, tables. Published by the Pennsylvania State College, State College, Pa. Price 50¢.

TRANSPORTATION LINES OF THE MISSISSIPPI RIVER SYSTEM — Transportation Series No. 4, 1936. Paper; 6 x 9 in.; pp. 124; halftones, tables, maps. Prepared by the Board of Engineers for Rivers and Harbors, War Department. For sale by Superintendent of Documents, Washington, D. C. Price 25¢.

THE DREDGE "CHIEN SHE" (1936)—General Series No. 15. Paper; 9 x 11½ in.; pp. of text 23; numerous halftones, linecuts, maps, tables. Published by the Whangpoo Conservancy Board, Shanghai, China. Price $4.00.

ANNUAL REPORT (TECHNICAL) OF THE WORK OF THE CENTRAL BOARD OF IRRIGATION, INDIA, 1934–35 — Central Board of Irrigation, Publication No. 11. Board; 8 x 13 in.; pp. 106; linecuts, tables. Published by Central Board of Irrigation, Simla, India.

THE STEEL PHYSICAL PROPERTIES ATLAS — By Charles Newman Dawe. Cloth; 8½ x 11 in.; pp. 87; tables, color charts. Published by the American Society for Metals, Cleveland Ohio. $2.50. ***Through an error in printing a notice of this book in our issue of Oct. 29, the price was incorrectly stated.***

ENGINEERING NEWS-RECORD

Volume 117, No. 22

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November 27, 1936

End the Dispute

USE OF SALT to remove ice on concrete pavements is arousing the concern of a number of state highway departments. Frequent damage from scaling is being discovered, particularly at intersections, at underpasses and on sections of roads through city streets. The use of salt to mitigate the special hazards of ice in these locations is common, and often it is not too well regulated. Unfortunately for definite conclusions, scaling of pavement concrete has too many possible causes to permit of certain proof that salt is the responsible evildoer, and those who find it a convenient aid are refusing to admit that their ice-removal practices are at fault. Opinion on both sides lack definite evidence. But the fact remains that scaling is common where salt is used and that it has reached proportions large enough to call for active investigation of cause and prevention. Bandying accusations will not meet the situation; the time has come for research to determine the facts.

Toward Reform

A GREAT FORWARD STEP in public-works activities might be realized if the resolution adopted by the Conference of Mayors last week could be carried into effect. The resolution urged a survey of municipal financing practices by impartial national authorities. As everyone knows, municipal finance has many strange aspects, and a thorough survey cannot fail to reveal numerous factors that hamper the prosecution of the betterment works for which the citizen pays or is ready to pay. Among them will be found bad programming, loose financial housekeeping, reckless practice in allowing bonds to outlive by many years the works against which they were issued, diversion of service revenues and the resulting distortion of rate structures and deterioration of essential community service facilities. Another group of factors will probably include unethical practices of bond houses in urging cities to borrow more than they need, as well as excessive interest rates. Such evils have been common enough to make it certain that reform will follow full publicity on financing practices. Reform in turn would open the way to rational works planning and programming.

An Example of Works Planning

ANALYSIS OF COMMUNITY NEEDS as a basis for works planning is rare, but any city that undertakes it is likely to find a long-term campaign of improvement construction necessary. Such an analysis in Milwaukee has resulted in the recommendation that an $18,000,000 program of public works be carried out within the next seven years. A still more unusual fact of Milwaukee's case is that the program will require no increase in taxes, as its cost can be met by retaining the present tax rate as debt retirement payments decrease. The program includes sewers, street construction, modernization of drawbridges, public buildings, grade separations, and playgrounds—items selected from returns from division heads, who submitted projects totaling $55,000,000. The Milwaukee example indicates clearly that looking ahead has its compensations; many other cities could profitably follow the same course of making a dollars-and-cents appraisal of future needs and laying down a definite improvement schedule. Whether Milwaukee with its large volume of needed works might not find it good business to enlarge the $18,000,000 program by some additions to its outstanding bonds is doubtless well worth consideration at the present low level of bond interest rates. But such a question of credit management is a local matter; the example of advance planning and programming of works is applicable to every city.

When Not to Hurry

ONE OF THE MINOR POINTS that the structural engineer will note with special interest in the excellent story of the East Bay bridging work that appears this week is the care taken to revise the dead-load calculations before the final design of the long spans was sent to the shop. It is not hard to remember past cases of difficulty or danger that resulted from lack of care in revising the dead-load estimates in long-span bridge work, not through gross incompetence or error in the original design work but as a result of the inevitable changes during the slow progress of detail designing. It is obviously vital that time be taken to recalculate dead weights after the detail designs are complete, and from these revised weights to recompute the design and modify the sizes of members where required by these results. Unfortunately, however, most bridge work is under greatest pressure for hurry just at the time the first detail drawings have been completed; the builder wants to order and fabricate his materials, the erector wants to proceed with planning his equipment and operations in the field, and the owner insists on getting work under way at once, in the not unnatural belief that a finished shop drawing means a finished and adequate design. The risk of hurrying at the wrong time is now more widely appreciated, and the fact that large undertakings such as the Bay Bridge give it careful recognition is one of the incidental but important evidences of bridge engineering advance.

Professional Discipline

TWENTY-NINE ENGINEERS have had their certificates revoked by the California board of registration for civil engineers in the six years since the board was established. The number exceeds the total of revocations by all the other state licensing boards put together, a fact that speaks volumes for the energy and courage of the California board. Further evidence of courage appears in the fact that California follows the unusual practice of making public its findings so that all may know of the justification for such drastic action as license revocation. This publicity is certain to exert a helpful influence. It reduces the likelihood that licenses will be revoked for minor causes, and on the other hand it will estop the man whose license has been revoked from charging that he has been made a victim of personal spite—as has occurred when technical societies have expelled members without other statement of reason than the vague "for cause." Of course a state license board has an advantage over a voluntary society in respect to legal immunity, since it is a public agency clothed with definite power. Yet the practice of the medical profession indicates that

even a voluntary organization can take strong disciplinary action in a public way so long as the action is free from prejudice. Professional discipline is so essential to maintenance of adequate ethical standards that the California board is entitled to the thanks of the engineering profession. Its vigorous action will do much to uphold the profession's standards.

Facts on Silicosis

CONSTRUCTION today finds itself concerned with a mystery of medical science. Silicosis, one of many obscure dust diseases in industry, has long been known as a rare plague of workers in rock, and in the Rand mining region it has been studied for many years; yet its hazards and control in construction still are largely unexplored. Recent legislation, however, makes it the necessary business of every construction man to know about silicosis and to deal with it.

In four different states silicosis is specifically defined in the law as a compensable disease, and in many others it may find tacit inclusion under the general term of occupational diseases. One state has a mandatory law requiring preventive control measures. Thus, construction jobs over a large area of the country are potentially subject to silicosis damage claims.

The truth is that silicosis is far from being as serious as many believe. A highly distorted picture has been drawn of it, by the effect of maudlin sentiment in company with ignorant talebearing and manufactured evidence. The silicosis hazard must not be taken lightly, but on the other hand it needs to be divested of the atmosphere of sensationalism with which it has been surrounded. Unfortunately the men of the construction industries, much more than those engaged in mining and stoneworking, are largely ignorant of its true proportions, the nature of the hazard, and available means of protection.

To meet this condition ENGINEERING NEWS-RECORD has obtained the statements of leading authorities on silicosis as it affects the construction engineer and the contractor. Grouped in three articles, of which the first is published this week, these statements discuss the broad health aspects of silicosis, including causation, detection of harmful dusts, and pathological effects; next the known practical methods of dust control; and finally the present status and trend of legislation and compensation. It is hoped that through these articles construction men will be equipped to deal with silicosis problems more intelligently and be enabled to take effective action to protect their workers and their operations against its hazard. They should also be placed in a better position to follow the progress of further study of the disease, and contribute their experience toward its final complete control.

It is quite unnecessary to emphasize that the existing laws designed to protect rock workers from being permanently disabled by silica-dust poisoning cannot safely be ignored by anyone connected with construction. Nor is it necessary to say that the good sense and human instincts of engineers and contractors will lead them to fight silicosis dangers in any part of their work, once they have become thoroughly familiar with these dangers.

Intensive field study of minimum safeguards against the occurrence of silicosis hazards in rock construction is now in progress by the New York State industrial department. Such study is badly needed, in view of the many unsolved problems connected with silicosis. Scientific and technical study must continue for a long time if we are to attain full protection. The mysterious disease will therefore continue to be of concern to the construction industry, and contractors and engineers who heretofore have ignored it are bound to give it close attention in future. If the articles whose publication is begun in this issue prove helpful in informing them about the practical aspects of silicosis in construction, the purpose of the authors and editors will be fulfilled.

Place for Conservatism

IN DEALING WITH FLOODS the engineer is in a peculiarly difficult position. He has to consider the demands of nature on the one hand and those of public psychology on the other, and very often the two conflict. Nature's demands are imperative, but only too often the requirements that the public seeks to impose appear much more urgent. If anywhere, then, a high degree of conservatism is in place in this field of work.

The engineer is required to provide for undetermined chances of future happenings that involve the possibility of disaster. His work depends on prediction—for the results of even the most extensive river observation are merely a basis for forecasting, and forecasting after all its prophecy. Flood-protective design is therefore a matter of providing for probabilities (or even possibilities) with a margin of safety that is sure to be adequate and yet will not go beyond the limits of reasonable economy. Matters are made still more difficult by the fact that increase of safety margin usually runs the cost up at increasingly rapid rate.

In contrast with these demands of nature, public psychology wants flood protection but usually is unwilling to face the large bill that thoroughgoing protection involves. It is apt to believe that 60 or 80 per cent of full flood protection is nearly as good as 100 per cent—wholly overlooking the disastrous possibilities of surplus flood volume overtopping its dams or levees and sending destructive torrents over the community. It is the engineer's prime duty to impress upon the public the fatal danger of this attitude.

Various other complications also enter the problem. The values at risk must be considered; when very large values are to be protected, a large safety margin is in order, while small values do not warrant equally ample protection. And after all the matter remains one of probabilities, since no one can say with absolute assurance what the ultimate flood limit may be. A rare sureness of judgment is therefore necessary in proportioning degree of safety to degree of risk—a consideration that applies with most compelling force to the spillway provisions of earth dams.

To repeat, conservatism must be the engineer's watchword in flood matters. His work is to protect against floods, not to serve popular fancies. He must not merely guide his own actions by conservative reasoning, but he must succeed also in converting the popular mind to a truly constructive attitude. In these days of widespread flood-control activity especially, it is important to bear in mind the supreme position of conservatism in the flood field.

CURRENT NEWS

Associated General Contractors Hold Fall Meeting

Problems of future public works, labor relations, skilled labor shortage and subcontractor relations were reviewed

With some fifty members in attendance the governing and advisory board of the Associated General Contractors met at Washington, D. C. on Nov. 16 and 17 to consider present conditions of the industry and problems calling for association action. Probable future funds for public works, subcontractor relationship, social security, labor relations and legislation particularly in connection with possible enactment of a law reestablishing the requirements of the old NRA regulations of business were discussed. Action was taken renominating the present officers W. A. Klinger, president, and E. P. Palmer, vice-president at large to serve during 1937. It was voted to hold the annual meeting at San Antonio, Tex., in February at a date to be named by the board of directors.

Skilled labor shortage

Reviewing the present year's work E. J. Harding, managing director, called attention to the growing activity in construction and stated that with present resumption amounting only to a fraction of predepression volumes a shortage of skilled labor was confronting contractors. Some of this was due to the retention of such labor in WPA activities but in actuality there was a true shortage due to cessation of training during depression, old age, death and change of occupation. Definite action to restore apprenticeship and to support trade schools and agencies for vocational training was urged by Mr. Harding.

In the general round-table discussion testimony was universal that a sufficiency of skilled workmen was lacking but in the face of denial by federal agencies it was necessary to present positive factual evidence. Action was taken to see what facts could be secured. It was freely charged that two conditions which militated against enlistment of young men in the skilled trades were opposition by organized labor and no definition and classification of skill by the federal department of labor. If no distinction in wages was made between hatchet and saw men and cabinet makers and all were classified as carpenters there could be little inducement for boys to spend time in learning to be skilled.

Labor relations

Question was raised whether the national association should continue its policy of countenancing no working agreements with organized labor. It was pointed out that starting with the original Davis-Bacon act requiring the payment of prevailing wages on federal building work, labor conditions in the construction industry have changed rapidly. Under the administration of this act experience has demonstrated that the union scale of wages has been determined to be prevailing in most instances. The original law has since been amended to include all construction to which the federal government is a party. The principle of payment of the prevailing wages has since been extended to include all PWA work and also all federal-aid highway work. A great number of states and lesser subdivisions of government have followed federal practice until at this time practically all contracts for public works require the payment of wages that are equal to any union wages as a minimum. As a result local contractors' organizations are meeting more and more insistence by organized labor for collective bargaining and already numerous chapters of the AGC have as AGC-organizations entered into labor agreements.

On the basis of the facts the round-table opinion was that action be taken to bring full information before the association in annual convention. It was the general opinion that while the national body should in no way indicate whether or not chapters

(*Continued on page 766*)

PWA Allots $13,000,000

The Public Works Administration on Nov. 23 approved 272 projects involving grants of $12,015,000 and loans of $1,541,000 for projects having a total cost of $25,336,000.

The largest allotments include a grant of $2,351,000 to the city of Chicago for repair and construction of 20 school buildings costing $5,225,000; a grant of $2,523,000 to Cook County for 46 paving jobs costing $5,607,000.

The bulk of the projects are relatively small and if the usual type, such as schools, water and sewer extensions, and paving.

Boring Bids Asked for Battery Tunnel

On Dec. 1 the New York City Tunnel Authority will advertise for bids on the taking of borings under the East River between the Battery, Governor's Island, and Hamilton Ave., Brooklyn, N. Y. These borings are intended to permit completion of plans for the proposed Battery-Hamilton Ave. vehicle tunnel. Preparation of plans has been under way for the past six months.

Under the proposed plans for the tunnel, the route will extend from the Battery, under the river to the northerly point of Governor's Island, and thence to the foot of Hamilton Avenue in Brooklyn. The new Manhattan approach would be at West St. and Battery Place, and the new Manhattan exit in the vicinity of Washington and Morris Streets. In Brooklyn the entrance and exits would be in the vicinity of Hamilton Ave. and Hicks St. The plans have been so drawn that no permanent construction for the tunnel would need to remain on the surface of the Battery Park.

The route passing under the tip of Governor's Island was adopted because it would permit the erection of an intermediate ventilation building on Governor's Island. The intermediate point of ventilation would enable a considerable saving in the yearly operating cost of the tunnel, and the additional ventilation shaft would provide the contractor with an intermediate point of construction.

Talbot Receives Fritz Medal

The 1937 John Fritz gold medal for scientific or industrial achievements has been awarded to Arthur M. Talbot, professor emeritus of civil engineering at the University of Illinois. The award is made annually by a board composed of sixteen past presidents of the four national engineering societies. The award was made in recognition of Professor Talbot's career as "molder of men, eminent consultant on engineering projects, leader of research and outstanding educator in civil engineering."

Professor Talbot was born in 1857. In 1881 he was graduated from the University of Illinois with the degree of bachelor of science and civil engineering and was awarded the professional degree of civil engineer in 1885. For four years after his graduation he worked on railroad location, construction and maintenance for the Denver & Rio Grande Railroad and the Atchison, Topeka and Santa Fe Railroad. In 1885 Mr. Talbot was appointed assistant professor of engineering and mathematics in the University of Illinois, and, in 1890, professor of municipal and sanitary engineering and put in charge of theoretical and applied mechanics, a position he held until his retirement in 1926 as professor emeritus.

Throughout his career, Professor Talbot has been interested in engineering research. He aided in the formation of the engineering experiment station at the University of Illinois and through twenty years has contributed to its methods and standards. By his own work and by that of his students he has contributed materially to the progress of research on reinforced concrete. Since 1914 he has been in charge of the research work of the Joint Committee on Stresses in Railroad Tracks of the American Society of Civil Engineers and the American Railway Engineering Association.

The University of Pennsylvania conferred on him the honorary degree of doctor of science in 1915 and the University of Michigan that of doctor of engineering in 1916. In 1924 he received the Washington award of the Western Society of Engineers. He is a past president

of the American Society of Civil Engineers, a charter member and past president of the Society for the Promotion of Engineering Education, and a past president and honorary member of the American Society for Testing Materials.

Jordan Honored at Indianapolis

Members of the Indiana Section of the American Water Works Association held a special dinner meeting on the evening of Nov. 17 in honor of Harry E. Jordan, former section president, who is to assume the office of executive secretary of the American Water Works Association on Dec. 1. About 40 persons attended from all parts of the state.

In recognition of his services, Mr. Jordan was presented with a set of Dunhill pipes. Talks were given by D. A. Poole, president of the Indiana Section; H. F. Morse, manager of the Indianapolis Water Co.; and C. K. Talvert, past president of the section.

It was decided to hold the spring meeting of the Indiana section in Indianapolis. The date has not yet been decided upon.

Long Island Parkway Link Opened to Bethpage Park

Parkway access to another Lonk Island recreation area was provided on Nov. 14, with the opening of the Bethpage Parkway connecting the Southern State Parkway at Massapequa with Bethpage Park. In contrast with the bathing and boating facilities of Jones Beach Park on the ocean, Bethpage offers golf, riding and hiking in a 1,000-acre hilly area near the center of the island.

The new parkway, 3 miles long, is provided with two lanes of pavement and is graded and landscaped to permit the addition of another lane on each side. Five grade separation structures, one of which accommodates the Long Island Railroad, pass over the new parkway. In his remarks at the opening exercises, Robert Roses, president of the Long Island State Park Commission, also announced the acquisition of new right-of-way, provided by Nassau County, for another parkway across the island connecting Northern State Parkway with the Wantagh causeway to Jones Beach. Funds for construction will be sought at the next session of the legislature, so that the new route will be available to world visitors in 1939.

The Long Island State Park Commission expects to start construction on the extension of the Northern State Parkway early in 1937 if funds are made available by the Legislature. The Northern State Parkway will be extended from its present terminus at the Jericho Turnpike through the village of Westbury as far as the Wantagh State Parkway extension. Plans call for two 24-ft. roadways separated by a 9-ft. mall with grade eliminations at all principal intersections. Preparation of bridge plans are well under way, and the project will be advertised as soon as the necessary appropriations have been made available.

Opens New York Office

The opening of a New York office has been announced by G. B. Gascoigne and Associates, consulting sanitary engineers of Cleveland. The new office, under the management of Charles A. Emerson, Jr., will be located in the Woolworth Building.

The Gascoigne organization has been established about 15 years, during which time it has served about 150 municipalities in matters pertaining to water supply, sewage and garbage disposal, and valuation and rate investigation. Mr. Gascoigne, previous to his work as a consultant, was in the employ of the city of Cleveland on the development of its sewerage and sewage treatment program. His associates include W. L. Havens, H. H. Burger, F. C. Tolles, and F. W. Jones.

Mr. Emerson, who will be in charge of the eastern office, has been associated for the past 14 years with Fuller & McClintock, consulting engineers of New York City. Before this he was chief engineer of the Pennsylvania State department of health for ten years.

Indiana Highway Commission Prepares for Winter

Purchase of 194 snow plows and 61 graders by the Indiana State Highway Commission to supplement present snow fighting equipment brings the snow fighting equipment of the maintenance division of the highway commission to about 520 snow plows and 366 graders.

In addition to the purchase of the snow plows and graders, the highway commission is taking bids for furnishing 40,000 ft. of snow fence which will be used along state highways in the LaPorte and Crawfordsville districts. About 100,000 tons of sand and cinders, 500 tons of calcium chloride, and 300 tons of salt is being stocked by the state highway maintenance forces for winter use.

Hume Reservoir in Australia Completed

On Nov. 20 water was released through the outlet valves of Hume Reservoir on the Murray River in Australia, marking completion of a dam and reservoir project which will store 2,000,000 acre-ft. of water and create a 60-sq.mi. lake.

Hume dam is the largest unit of an extensive program for conservation, irrigation, and navigation improvements on the Murray River which has been under way since 1919. The entire program involves the construction of about 35 locks and weirs to control the water.

Hume dam is an earth-fill type with a reinforced concrete core. It is 5,200 ft. long and has a maximum height of 138 ft. The upstream slope of the dam is paved with concrete blocks laid on 6 in. of gravel, and the downstream side is faced with gravel about 4 in. deep. The spillway is designed for a maximum flow of 8,000 sec. ft. There are seven outlets, three of which will be used for a hydro-electric plant generating 40,000 kw. The outlets are controlled by stoney sluice gates and 7-ft. 6-in. needle valves. All outlets discharge into a concrete stilling pool with a depth of 22 ft.

The dam was built at a cost of $27,500,000. The entire Murray River project will cost about $75,000,000, of which about $52,000,000 has already been spent.

All-American Canal Gets Allotment

PWA allots three million for first power generating unit and distributing system on the All-American Canal

The All-American Canal, which was authorized by the Boulder Canyon Project Act, is 80 miles long. It taps the Colorado River 15 miles north of Yuma, Arizona, and flows westward along the Mexican border to the Imperial Valley in California, which is below sea level. There are four potential power sites, all of which will eventually be developed by the district. This power development is incidental to the irrigation of about 1,000,000 acres of land. In the future development 170,000 acres will require the pumping of irrigation water, which will be done using power generated by the canal. The All-American Canal has an average capacity of 10,000 cu.ft. per sec.

The Imperial Irrigation District has also secured from the Rural Electrification Administration an allotment of $700,000 for the construction of distribution lines, but this money will not be available until the project is approved by popular vote and certain legal difficulties are cleared up. The Imperial Valley is now served by the Southern Sierra Power Co., from generating plants located elsewhere, over long transmission lines. According to the Irrigation District, this has resulted in high power cost and inadequate distributing systems.

Subway Contracts Let

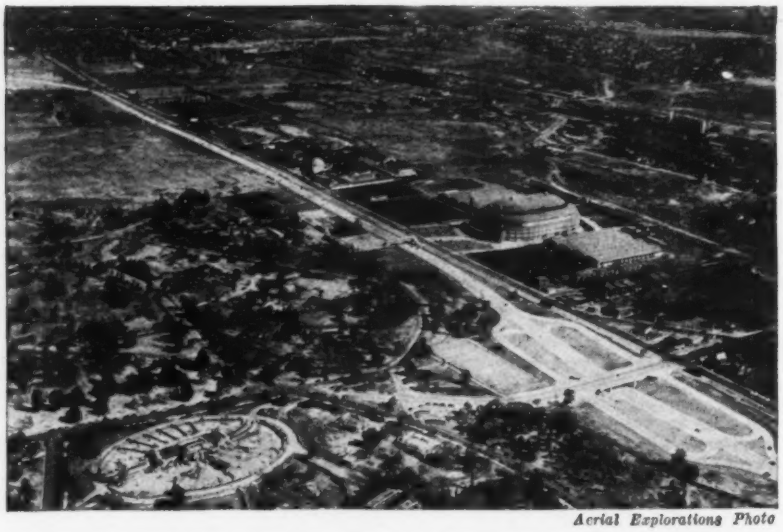
Contracts for the construction of the fourth section of the New York City Sixth Ave. Subway was awarded by the New York City Board of Transportation to the George H. Flinn Corporation, the low bidder. The Flinn bid was $4,616,000.

The fourth section is from 47th St. to 53d St., where the line will connect with the present Queens extension, which runs from the 8th Ave. line under 53d St. to Queens. Construction on the first three sections, covering the distance from 27th to 47th Sts. is already underway. On Dec. 11 the board of transportation will open bids for the fifth section extending southward from 27th to 18th Sts. The line will join the 8th Ave. line at West 4th St.

Paving Brick Association Sets Meeting Date

The National Paving Brick Association will hold its 31st annual meeting in Detroit on Jan. 27-29, 1937, at the Book-Cadillac Hotel. Most of the sessions will be open to the general public.

Recent developments in paving brick production and utilization, including descriptions of modern brick street and highway paving and resurfacing projects, will be covered in papers by prominent engineers and contractors. The research bureau maintained by the National Paving Brick Association at the Ohio State University experiment station will present a resume of its work, including reports on recent researches on fillers, bed courses, and methods of laying brick.



Aerial Explorations Photo

NEW OAKLAND EXPRESS HIGHWAY IN ST. LOUIS

Opened to traffic for its full 3-mile length this fall, the Oakland express highway in St. Louis, leading from the city limits toward the business section, is the first of its type to be built in the Middle West. All traffic and pedestrian crossings are carried over the 5-lane roadway on bridges, of which there are thirteen. The main traffic bridges are steel rigid frames.

A mile to the right of the grade separation in the foreground is the city limit, where the highway connects with U. S. route 40. The last mile, beyond the left extremity of the view, is depressed in a new right-of-way through former slum property. Most of the overhead bridges are in this mile length. The express highway now ends in Vandeventer Avenue and in Chocteau Avenue. The Oakland express highway was built by the Missouri State Highway Department and was described in *ENR*, Dec. 19, 1935, p. 846.

Associated General Contractors

(*Continued from page* 764)

should enter into labor agreements but leave this for local decision, it should adopt a policy sufficiently flexible to permit it to advise chapters of practices, to develop uniform action, to guard against agreements that interfere with managerial control and to have agreements properly limited as to territory and type of work.

Testimony has been increasing that the relations between general contractors and subcontractors were reaching a condition which calls for readjustment. A report from the association staff and discussion from the floor indicated definite action by certain subcontracting trades to perpetuate former code practices with the backing of organized labor and to organize protection against bid shopping by bid depositories or separate contracts. Bid depositories as practiced are taking two forms: (1) founded as a joint compact or code of fair competition to which the general contractor is a party and (2) operated entirely independently of the general contractor and depending for its enforcement upon an understanding with labor. Under the second procedure the evidence indicates that there is a two-fold purpose (1) the control of bids and (2) the forcing of the general contractor to sublet an increasing proportion of his work.

In the discussion, which brought out charges of collusion and law infraction, it appeared that (1) general and subcontractor relationship varied from close cooperation to open antagonism (2) in many sections certain trades supported by labor were in a position to dictate that the general contractor must sublet all work of that trade and (3) pressure for statutory requirement of separate contracts is undiminished. Determination on action was only to carry the question to the association in annual convention.

Prospective legislation

In reporting the committee on legislation laid on the table for discussion the fact that most of bills of the last Congress that vitally affected construction were slated for consideration in the coming Congress, that legislatiin establishing former NRA control of industry was probable and that meanwhile contractors had before them the task of adjusting their business to carry out the terms of the present Social Security Act. It developed in the discussion of the last subject that pending court action on constitutionality indicated the desirability of making payment under protest. In conclusion it was ordered that legal opinion be secured on possibilities of recovering payments in case the act was adjudged unconstitutional.

Discussion waxed sharp on a possible law restoring regulation of industry. Objection to any restoration of NRA regulation was positive, unanimous and cynical. The question of representation at the coming conference of the coordinator for industrial cooperation swung between opposition to any part in the conference and active participation. A vote decided that representatives "without portfolio" should attend. This decision rested on the basis that legislation was inevitable and the wiser action was to take part and act as moderator as far as possible.

Reports were presented on insurance, safety, gasoline tax diversion, creating new construction and association activities and were accepted without action. The report on future public works will be published in *Engineering News-Record* of Dec. 2.

Amendment Unlikely for Walsh-Healey Act

Washington Correspondence

OFFICIALS charged with the administration of the Walsh-Healey Act have no desire to see it amended at the next session of Congress. They would like to have more experience with the act before recommending changes. In this they will be supported by the leaders in each House, most of whom are conservative Southerners.

The only development that might force substantial amendment would be the refusal of manufacturers to bid or holding restricted exclusively to dealers.

There is no real opposition among government purchasing agents to split bids which drop below the $10,000 exemption limit. The Procurement Division of the Treasury rejected several sets of bids for trucks when submitted in units of less than $10,000, but when no bids were made on any other basis, split bids were accepted.

No real test of the act can be had, however, until prevailing wages have been determined. This is being undertaken by industry. That many difficulties have been encountered is indicated by the fact that no finding has been returned on the first study undertaken, that of the work-clothing industry. Orders for uniform cloth have continued to go to a manufacturer who was mentioned in the hearing as the type it is desired to eliminate. There could be no real showdown in that case, however, until prevailing wages are determined. Even then it is doubted that much change will take place. Under the wording of the law, only a minimum wage prevailing in the particular industry can be fixed.

Some difficulty is being experienced in securing representatives of labor and busines for an advisory panel on minimum wage determination. Various trade associations have been invited to suggest names. Nominations undoubtedly will be submitted, since Washington representatives of trade associations are opposed to any action that would give grounds for the charge that industry is opposing enforcement of the law. Organized labor is already asking for a punitive measure.

Excavation Tunnel Completed At Fort Peck Dam

Excavation of the four diversion tunnels at Fort Peck dam was completed on Nov. 18 when the enlargement of Tunnel No. 4 holed out at the inlet portal. Col. T. B. Larkin, U. S. District Engineer, placed the final bolt in the last ring section of ground support at 10 a.m., marking the end of 23,828 lin. ft. of 30 and 32-ft. tunneling through treacherous Bearpaw shale.

The first heading was turned Aug. 16, 1934, with start of pilot bore tunneling, which was completed in all four tunnels before enlargement to full size commenced. Tunnel excavation, exclusive of shafts and open-cut work at the portals, amounted to 915,280 cu. yd. More than 29,000 tons of structural and reinforcing steel has already been placed in the tunnels, and more will follow as the concrete lining is completed. Placing of the concrete lining will be completed shortly, and installation of the steel penstock in the lower part of Tunnel No. 1 is well under way. Steel and concrete lining for the four large control shafts is nearing completion.

An analysis of dredging operations reveals that an average of 95 cu. yd. of fill was placed in the dam every minute of the 204-day 1936 dredging season, aggregating more than 28,000,000 cu. yd. Dredging started this year on Apr. 15, and ended Nov. 5 after consistent cold weather had frozen the core pool. The following tabulation shows how the output of the dredging plant steadily increased.

YARDAGE PLACED IN FORT PECK DAM, 1936

Month	Cu. Yd.
May	3,734,000
June	3,697,600
July	3,898,750
August	4,271,550
September	5,062,400
October	5,097,000

Pumping Plant Bids Called On Buffalo Sewer Project

The Buffalo, N. Y. Sewer Authority will open bids on Dec. 8 for the main pumping station on Bird Island of the $15,000,000 sewer project. The cost of the pumping station is estimated at about $860,000. Start of construction is planned before the first of the year, and work will be completed in December, 1937.

The pumping station will have a daily capacity of 570,000,000 gallons. Besides the main station on Bird Island, there will be two subsidiary pumping stations of lower capacity, one in South Buffalo and the other in a location not yet selected. The main pumping station will be of face brick and reinforced concrete construction. It will be 140 ft. long, 52 ft. wide, and 36 ft. below ground level. There will be six main pumps, each driven by a 600 hp. electric motor.

SOCIETY CALENDAR

ASSOCIATION OF WESTERN STATE ENGINEERS, annual meeting, Santa Fe, N. M., Dec. 3-5.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, MIDDLE ATLANTIC SECTION, fall meeting, New York City, Dec. 5.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual meeting, San Francisco, Calif., December 7-10.

AMERICAN SHORE AND BEACH PRESERVATION ASSOCIATION, annual meeting, Washington, D. C., Dec. 14.

AMERICAN ROAD BUILDERS ASSOCIATION, convention and highway exhibit, New Orleans, La., Jan. 11-15.

UNIVERSITY OF COLORADO, highway engineering conference, Boulder, Colo., Jan. 14-15.

AMERICAN ENGINEERING COUNCIL, annual assembly, Washington, D. C., Jan. 14-16.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting, New York City, Jan. 20-23.

NEW YORK STATE SEWAGE WORKS ASSOCIATION, annual meeting, New York City, Jan. 21-3.

AMERICAN WOOD PRESERVERS ASSOCIATION, annual meeting, New Orleans, La., Jan. 26-28.

NATIONAL PAVING BRICK ASSOCIATION, annual meeting, Detroit, Mich., Jan. 27-9.

LICENSE EXAMINATIONS

IOWA, examination for professional engineering on Dec. 1-2, and for land surveying on Dec. 1-2, and for land surveying on Dec. 3, at the State House, Des Moines, Iowa.

MICHIGAN, examination for architects at the University of Michigan and for engineers and surveyors at the University of Michigan, and at Michigan State College and Michigan College of Mines, and at Ironwood, on Dec. 28-30.

Pollution Treaty Discussed At Interstate Conference

Representatives of five Ohio valley states met at Cincinnati on Nov. 20 in a conference called by the governor of Ohio (*ENR*, Aug. 27, 1936, p. 319) to discuss the possibility of an interstate compact for the control of stream pollution along the Ohio River and its tributaries. The states represented were New York, Ohio, Kentucky, Indiana, and Illinois.

The meeting resulted in the formation of a temporary organization known as the Ohio Valley Treaty Commission with William F. Wiley of Cincinnati as chairman and Fred M. Waring, Ohio department of health, as secretary. The governor of Ohio Valley states were asked to procure from their legislatures authority to enter a joint treaty for a program of stream purification.

Authority to negotiate interstate compacts for this purpose was granted by Congress in the Citron Act to states in the Ohio and Connecticut River Valleys.

Army Allots Funds for Surveys To Supplement Flood Data

The Secretary of War has approved an allotment of $200,000 for additional investigations in connection with surveys on the Connecticut River in Connecticut, Massachusetts, New Hampshire and Vermont and on the Susquehanna River in New York, Pennsylvania and Maryland, under the authorization contained in Section 6 of the river and harbor act of 1935. That act required that the surveys which were authorized in the river and harbor act of 1927 should be supplemented by such additional study or investigation as the Chief of Engineers found necessary to take into account important changes in economic factors as they occur and additional streamflow records or other factual data.

These additional studies are made so that the major floods of 1936 may be taken into consideration in the preparation of definite plans for the flood control projects in the Connecticut River and Susquehanna River basins which are authorized by Congress in the 1936 flood control act.

An allotment of $13,000 has also been made for similar studies on the Willamette River in Oregon, necessitated by important changes in economic practice in the Willamette valley. These investigations are now in progress and require additional funds for their completion.

Hoover Medal Awarded To Swasey

The Hoover medal for 1936 has been awarded to Ambrose Swasey. This medal recognizes public service rendered by an engineer. Herber Hoover is the only other person to whom it has been awarded. Mr. Swasey has achieved an international reputation through his research work in connection with the production of astronomical instruments of precision. Besides his various technical contributions to the engineering profession, Mr. Swasey made the initial gift which established the Engineering Foundation.

Mr. Swasey was born in 1846 in Exeter, N. H., and learned the machinist trade in his native town. In 1870 he entered the employ of the Pratt & Whitney Co., machinery manufacturers at Hartford, Conn. In 1880 he went to Cleveland, Ohio, and entered into partnership with W. R. Warner, under the firm name of Warner & Swasey.

Mr. Swasey is an honorary member and past president of the American Society of Mechanical Engineers and an honorary member of the American Society of Civil Engineers. In 1924 he received the John Fritz medal.

Highway Bodies Will Study Road Safety

The causes of highway accidents and the conditions contributing to them are the subjects of a joint study to be made by the Bureau of Public Roads and the Highway Research Board of the National Research Council. The Bureau of Public Roads is initiating this program under an act of Congress of last June which authorized an expenditure of $75,000 in investigating traffic conditions and the formulation of corrective legislation.

The study will consist of an analysis of the accident records of a large number of drivers, covering a considerable number of years. The study will be confined to states and cities where adequate records have been kept.

An advisory committee to assist in the study has been appointed. The committee consists of Dr. H. C. Dickinson, Bureau of Standards; Prof. C. J. Tilden, Yale University; Dr. Harry DeSilva, Harvard Traffic Research Foundation; Prof. A. Lauer, Iowa State College; Robbins B. Stoeckel, Yale University; Sidney J. Williams, National Safety Council; Burton W. Marsh, American Automobile Association.

Obituary

J. H. ROBINSON, 78, civil engineer and county surveyor at Gunnison, Colo., died in that city on Nov. 12.

WILLIAM ROPES, sanitary engineer died on Nov. 20 in New Rochelle, N. Y. at the age of 60. Mr. Ropes was a graduate of Columbia University with a civil engineering degree. He was active in government malaria control work in the South during the war.

ODON O. MELANCON, assistant Louisiana state engineer since 1929, died in New Orleans on Nov. 13 at the age of 50. Before becoming assistant state engineer, Mr. Melancon, a graduate of the engineering college of Louisiana State University, had been in private practice for 6 years and for 13 years before that had been connected with the U. S. Engineer Department. partment.

ERNEST R. GRAHAM, architect, died in Chicago on Nov. 21 at the age of 68. Mr. Graham was the senior partner in the Chicago architectural firm of Graham, Anderson, Probst & White. He was a graduate of Poe College and Notre Dame

University. Among the buildings he designed in Chicago were the Merchandise Mart, the Field Building, the Wrigley Building, the Field Museum, Shedd Aquarium, Continental Illinois Bank Building, the Union station, the new postoffice, the Pittsfield building, the State Bank of Chicago building, and the Civic Opera building. Among the structures he designed in other cities are the Equitable, the Flatiron, and the Chase National Bank buildings in New York City; the Union station and general post office in Washington, D. C.; and the Union Trust, the Union station, and the Terminal Tower buildings in Cleveland.

CAPT. RICHARD C. HOLLYDAY, Civil Engineers Corps, U. S. Navy, retired, died on Nov. 17 at Easton, Md. at the age of 77. Captain Hollyday was a graduate of Washington and Lee University. He later studied law and was admitted to practice. For four years he was in the employ of the Baltimore & Ohio Railroad as an assistant engineer and later as engineer of maintenance of way. In 1894 Captain Hollyday was appointed a civil engineer in the Navy with the rank of lieutenant, junior grade. He became a lieutenant in 1897, lieutenant commander in 1902, and commander in 1906. In 1907 he was appointed chief of the Bureau of Yards and Docks, holding that position until 1912. He had attained the rank of captain in 1911. In 1912 he was assigned to duty in the Washington Navy Yard, in 1915 to the Norfolk Navy Yard as public works officer, and in 1918 to the New York Navy Yard. He retired in 1923.

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction awards, representing a short week due to Thanksgiving Day, total $50,152,000, of which private is $18,481,000; public, $31,661,000; federal, $7,517,000; state and municipal, $24,144,000. Corresponding values for a similar short week last year are: total, $41,863,000; private, $7,772,000; public, $34,091,000; federal, $3,662,000; state and municipal, $30,429,000.

Volume is higher this week in waterworks, sewerage, bridges, industrial buildings, earthwork, irrigation and waterways, and unclassified. The subtotals by classification are: industrial buildings, $12,342,000; commercial buildings, $3,707,000; public buildings, $6,957,000; highways, $6,318,000; bridges, $3,998,000; sewerage, $4,367,000; waterworks, $834,000; earthwork, drainage, $3,206,000; unclassified, $8,413,000.

The larger awards for the week include: power plant, Williamsburgh Power Plant Corp., Brooklyn, N. Y., $4,350,000; pulp plant, Brunswick Pulp and Paper Co., Brunswick, Ga., $3,500,000; plant improvements, Moline-Rock Island Mfg. Co., Bettendorf, Iowa, $1,500,000; superstructure, Laurel Homes Housing Project, Cincinnati, Ohio, $3,690,000; highways, by Illinois, $2,193,000; superstructure for double leaf trunnion bascule bridge, Chicago, Ill., $655,000; substructure and superstructure, bridge in Calhoun County, State Highway Commission, Florida, $825,000; 5¼ mile diversion sewer, Chicago, Ill., $1,208,000; 3 Diesel engine driven steel sludge vessels for Wards Island Sewage Treatment plant, Section 4, Contract 0, Department of Sanitation, New York, N. Y., $1,497,000; vertical lift gates and hoisting machinery at Emsworth Dam, Emsworth, Pa., $816,000; Dam No. 14, LeClaire, Iowa, $1,980,000; subway under 6th Ave., from 47 to 53 Streets, Section 11, Route 10, New York, N. Y., $4,616,000; 20,000 tons steel rails, Union Pacific Railroad Co., Omaha, Nebraska, is estimated at $800,000.

New capital for the week includes PWA allotments, $2,760,000; corporate security sales, $554,000; and state and municipal bond sales, $35,034,000, the largest week's financing this year for public works financed by private investment.

CONTRACTS
(Thousands of Dollars)

	Weekly Average Nov. 1935	Prev. 4 Weeks	Week Nov. 26 1936
Federal Government	$3,797	$4,089	$7,517
State and Municipal	22,871	20,988	24,144
Total public	$32,668	$25,077	$31,661
Total private	6,075	14,286	18,481
Week's total	$38,743	$39,363	$50,142
Cumulative to date:			
1935..$1,354,645,000	1936..$2,120,544,000		

NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

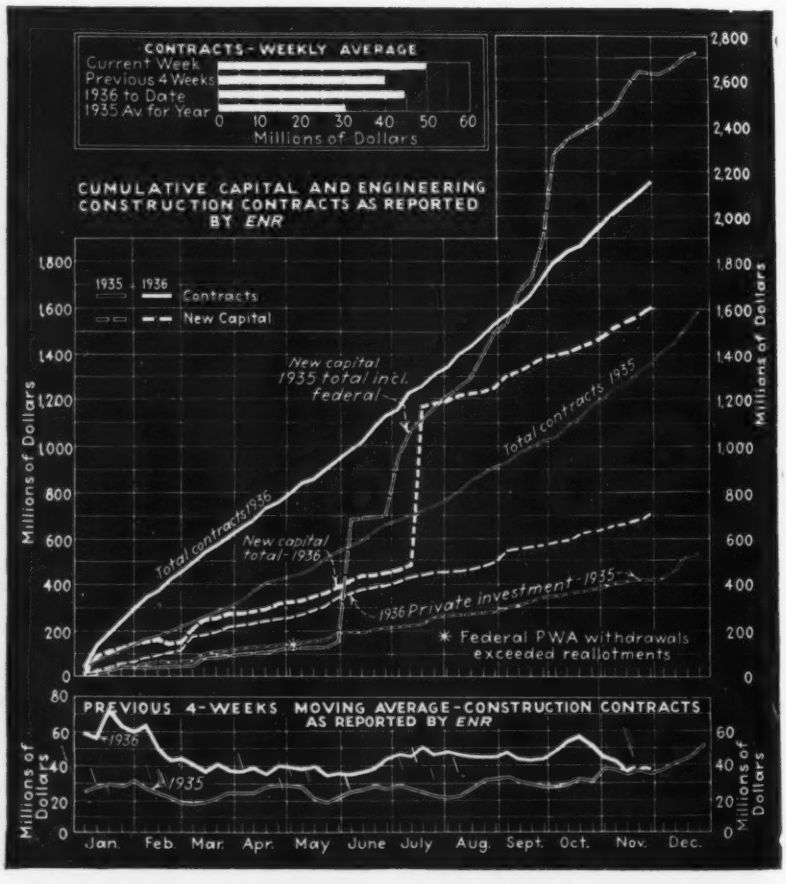
1936	Week Nov. 26	Cumulative
State and municipal	$35,034	$479,775
PWA non-federal	2,760	153,873
RFC loans	.....	26,663
Corporate issues	554	233,992
PWA loans, Private	.....	—1,665*
Total Non-Federal	$38,348	$892,638
Federal	.....	691,237
Federal	.....	.....
Total new capital	$38,348	$1,583,875
Cumulative to date:		
1935..$2,645,927,000	1936..$1,583,875,000	

*** Bond sales in this classification exceed reallotments during current year.**

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

INDEX NUMBER

EN Cost	1913 = 100	1926 = 100	EN Volume	1913 = 100	1926 = 100
Nov., 1936	212.70	102.24	Oct., 1936	178	78
Oct., 1936	211.50	101.67	Sept., 1936	200	88
Nov., 1935	194.90	93.69	Oct., 1935	162	71
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1936 to Date
1935 Av. for Year
0 10 20 30 40 50 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1935 + 1936
Contracts
New Capital
New capital 1935 total incl. federal
Total contracts 1935
Total contracts 1936
New capital total-1936
1936 Private investment-1935
* Federal PWA withdrawals exceeded reallotments
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936
1935
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Current Construction Unit Prices

Dam 14, Mississippi River

BIDS were opened Nov. 5, 1936, by the U. S. District Engineer, Rock Island, Ill., for the construction of Dam 14, one of the units in the 9-ft. canalization program of the Upper Mississippi River, located 4 mi. below Le Claire, Ia. The dam will be 2,700 ft. long to join the Illinois shore and Lock 14, which has just been completed on the Iowa side of the river. The structure includes four 20x100-ft. roller gates and thirteen 20x60-ft. tainter gates, a 200-ft. storage yard and 1,127 ft. of earth dike. Work must be completed within 730 calendar days. Minimum wage rates stipulated in the contract range from 50c. for common labor to $1.25 for bricklayers.

Six bids were submitted, with a spread of $338,751 between lowest and highest. The engineer's estimate was $2,190,031, or $210,169 above the low bid. Unit prices submitted by the three low bidders follow: (A) Central Engineering Co., Davenport, Ia. (contractor on the adjoining lock) $1,979,862; (B) Massman Const. Co., Kansas City, Mo., $2,096,451; (C) United Const. Co., Winona, Minn., $2,117,220.

DAM No. 14. MISSISSIPPI RIVER

Item	A	B	C
1. Cofferdam—1,448 lin.ft.	$104.00	$150.00	$100.00
2. Clearing—lump sum	250.00	500.00	721.00
3. Excav., common—1,000 cu.yd.	0.15	0.60	.94
4. Excav., topsoil—2,500 cu.yd.	0.20	.40	.76
5. Excav., rock—45,000 cu.yd.	2.71	2.00	2.74
6. Channeling, rock—16,000 sq.ft.	.95	1.10	1.30
7. Grout holes; first 10 ft.—1,400 lin.ft.	.40	.60	1.44
8. Grout holes, second 10 ft.—700 lin.ft.	.45	.75	1.44
9. Pressure grouting, cement—500 bbl.	6.50	7.00	7.64
10. Fill, common—1,200 cu.yd.	.60	.55	1.00
11. Embankment, dike—45,000 cu.yd.	.45	.60	.43
12. Piling, timber—1,600 lin.ft.	.45	.65	1.67
13. Piling, concrete—1,170 lin.ft.	1.75	3.75	4.08
14. Piling, 23 lb. steel sheet—8,000 sq.ft.	.93	1.50	1.31
15. Piling, 22 lb. steel sheet—31,500 sq.ft.	.50	.80	.74
16. Timber, white oak—4 M.f.b.m.	200.00	300.00	252.00
17. Timber, soft wood, plain and creo.—50 M.f.b.m.	158.00	200.00	170.00
18. Stone, rock fill—40,000 cu.yd.	.56	1.00	1.44
19. Stone, crushed or gravel—700 cu.yd.	1.40	3.00	3.02
20. Concrete, Class A—775 cu.yd.	21.50	25.00	30.72
21. Concrete, Class B—40,000 cu.yd.	12.39	12.60	12.87
22. Concrete, slushing—600 cu.yd.	12.50	12.00	14.09
23. Steel, service bridge—1,975,000 lb.	0.063	.065	.07
24. Steel, wall armor—92,000 lb.	0.043	.065	.11
25. Steel, tainter gate, mov. parts—1,825,000 lb.	0.0845	.085	.09
26. Steel, roller gate, mov. parts—1,236,000 lb.	.1285	.115	.11
27. Steel, misc. struct.—965,000 lb.	.072	.088	.10
28. Steel, struct., manganese—263,000 lb.	.0935	.10	.10
29. Steel, struct., chromium—75,000 lb.	.1075	.10	.15
30. Steel, reinf.—1,260,000 lb.	.043	.05	.05
31. Steel, corrosion-resisting—22,000 lb.	.6435	.65	.86
32. Forgings, steel—325,000 lb.	.109	.11	.14
33. Forgings, nickel steel—2,900 lb.	.564	.57	.60
34. Forgings, chromium steel—17,800 lb.	.22	.22	.25
35. Castings, steel—300,000 lb.	.151	.15	.18
36. Castings, alloy-steel—42,000 lb.	.185	.19	.22
37. Castings, iron—1,680 lb.	.132	.14	.11
38. Bronze—11,250 lb.	.729	.75	.87
39. Lead—650 lb.	.289	.30	.72
40. Pipe, ¼-in. w.i. std. blk.—300 lin.ft.	.85	.90	.26
41. Pipe, 18-in. culvert, 35 lin.ft.	1.65	2.00	2.50
42. Fence—760 lin.ft.	.32	.50	.42
43. Fiber conduit, 3 in.—10 lin.ft.	.65	1.00	.79
44. Fiber conduit, 2 in.—920 lin.ft.	.42	.75	.65
45. Rigid metal conduit, 3 in.—130 lin.ft.	1.40	3.00	3.61
46. Rigid metal conduit, 2 in.—120 lin.ft.	.85	2.50	2.81
47. Rigid metal conduit, 1½ in.—565 lin.ft.	.75	2.00	1.80
48. Rigid metal conduit, 1¼ in.—30 lin.ft.	.65	2.00	1.80
49. Rigid metal conduit, 1 in.—165 lin.ft.	.55	1.50	.94
50. Rigid metal conduit, ¾ in.—240 lin.ft.	.50	1.40	.65
51. Elec. grounding system—total	450.00	500.00	577.00
52. Crane track, 80-lb. rail—1,685 trk.ft.	4.10	4.10	3.99
53. Handrail, steel pipe—1,730 lin.ft.	2.28	2.30	2.31
54. Steel floor grating—235 sq.ft.	1.42	1.45	1.08
55. Moulded rubber seals—6,500 lb.	1.00	1.00	1.08
56. Central control sta., complete—total	23,500.00	22,500.00	15,000.00
57. Roller gate oper. mach.—4 each	23,550.00	22,500.00	24,517.00
58. Roller gate mach., spare parts—1 lot	910.00	910.00	4,326.00
59. Roller gate oper. house—5 each	4,500.00	5,000.00	5,487.00
60. Tainter gate oper. mach.—13 each	14,090.00	14,090.00	10,816.00
61. Tainter gate spare parts—1 lot	250.00	250.00	319.00
62. Tainter gate mach. spare parts—1 lot	8,515.00	8,515.00	8,326.00
63. Tainter gate heater—6 each	750.00	750.00	865.00
64. Tainter gare heaters, spare parts—1 lot	345.00	345.00	400.00
65. Roller gate heaters, complete—4 each	2,790.00	2,790.00	4,038.00
66. Roller gate heaters, spare parts—1 lot	885.00	885.00	2,625.00
67. Install. locomotive crane on serv. bridge—job	1,500.00	3,850.00	2,124.00
68. Storage yard truck—10 each	490.00	490.00	577.00
69. Service bridge truck—2 each	710.00	710.00	865.00

Fresno Dam, Montana

CONSTRUCTION of an earth dam, 2,100 ft. long and 80 ft. high, is proposed on the Milk River in Montana, 25 mi. south of the international boundary and 2 mi. west of the junction of U.S. Highway 2 and the Great Northern R.R., in accordance with bids submitted Oct. 30, 1936. The project is financed through PWA and is scheduled for 1,100 days completion with minimum hourly wage rates stipulated of $1.20 for skilled and 50c. for common labor. The government furnishes f.o.b. Fresno and dam site, cement, sand, stone, gravel, reinforcing steel, sheet piling, sewer pipe, drainage pipe, and all metal parts and mechanisms for permanent installation. The project is under the U. S. Bureau of Reclamation, Malta, Mont., office.

The unit prices, totals and quantities submitted by the three low bidders are given in the following tabulation: (A) Wachter-O'Neill Const. Co. and McGarry Bros., Bismarck, N. Dak., $980,804; (B) Tomlinson-Arkwright Const. Co. and J. L. McLaughlin, Great Falls, Mont., $1,195,937; (C) Martin Wunderlich, Jefferson City, Mo., $1,302,749.

FRESNO DAM, MILK RIVER, MONTANA

Item	A	B	C
1. Diversion, care of river—total	$15,000	$7,500	$10,000
2. Excav., strip borrow pits—73,000 cu.yd.	.10	.10	.23
3. Excav., strip embankment—111,000 cu.yd.	.15	.15	.35
4. Excav., spillway, tunnel inlet—321,000 cu.yd.	.265	.35	.60
5. Excav., outlet tunnel—4,500 cu.yd.	12.00	12.00	12.00
6. Excav., toe drains, cutoffs—200,000 cu.yd.	.25	.43	.35
7. Excav., concrete cutoff wall—400 cu.yd.	5.50	1.50	2.00
8. Excav., earth, borrow—1,975,000 cu.yd.	.165	.21	.22
9. Excav., rock, borrow—36,000 cu.yd.	2.10	4.00	3.00
10. Backfill—6,000 cu.yd.	.35	.60	.50
11. Earth fill embankment—1,725,000 cu.yd.	.05	.03	.04
12. Compacted earth fill—700 cu.yd.	1.00	1.10	2.00
13. Rockfill, downstream slope—147,000 cu.yd.	.20	.16	.20
14. Riprap, upstream slope—41,500 cy.yd.	.25	.20	.50
15. Dumped riprap in spillway—8,600 cu.yd.	.25	.20	.50
16. Sewer pipe drains, 4 in., porous conc.—1,325 lin.ft.	.75	1.00	.70
17. Sewer pipe drains, 4 in., gravel—575 lin.ft.	.25	.60	.50
18. Sewer pipe drains, 6 in., porous conc.—1,200 lin.ft.	.85	1.10	.80
19. Sewer pipe drains, 6 in., gravel—715 lin.ft.	.30	.70	.60
20. Sewer pipe drains, 8 in., porous conc.—770 lin.ft.	.95	1.25	1.00
21. Sewer pipe drains, 8 in., gravel—1,400 lin.ft.	.35	.80	.70
22. Sewer pipe drains, 10 in., porous conc.—350 lin.ft.	1.05	1.40	1.20
23. Sewer pipe drains, 12 in., gravel—2,000 lin.ft.	.40	.90	1.00
24. Lay 18 in. sewer pipe—40 lin.ft.	2.00	2.00	1.50
25. Lay 12 in. corr. perf. pipe—2,800 lin.ft.	.40	.50	.50
26. Lay 15 in. corr. perf. pipe—3,000 lin.ft.	.40	.60	.60
27. Gravel fill for drains—500 cu.yd	1.00	.80	1.00
28. Timber, pump sumps, shafts—40 M.B.M.	20.00	100.00	50.00
29. Porous conc. floor spillway basin—420 cu.yd.	6.00	8.00	10.00
30. Drill weep holes—1,000 lin.ft.	1.00	1.50	1.00
31. Drill grout holes to 25 ft.—1,200 lin.ft.	.75	1.00	1.00
32. Install grout, pipe fittings—42,000 lb.	.03	.04	.05
33. Pressure grout, cement—1,300 cu.ft.	1.00	2.00	1.00
34. Pressure grout, clay—6,750 cu.ft.	.50	.20	.50
35. Drive steel sheet piles—7,000 lb.	.10	.16	.12
36. Drill for anchor, grout bars—2,640 lin.ft.	1.00	.60	1.00
37. Concrete embankment cutoff—500 cu.yd.	8.00	10.00	10.00
38. Concrete, trash rack—210 cu.yd.	14.00	22.00	18.00
39. Concrete, outlet conduit—470 cu.yd.	16.00	18.00	18.00
40. Concrete, tunnel lining—1,100 cu.yd.	18.00	23.00	18.00
41. Concrete, gate chamber—550 cu.yd.	18.00	24.00	18.00
42. Concrete, spillway floor—6,700 cu.yd.	6.00	6.00	8.00
43. Concrete, spillway, except floor—3,600 cu.yd.	14.00	13.00	14.00
44. Concrete, control house—65 cu.yd.	18.00	30.00	40.00
45. Concrete, parapet, curb walls—810 cu.yd.	12.00	13.00	10.00
46. Place reinforcing bars—1,730,000 lb.	.015	.02	.015
47. Steel tunnel liner plates—115,000 lb.	.02	.08	.06
48. Install metal sealing strips—1,400 lin.ft.	.15	.50	.50
49. Special concrete surface finish—1,200 sq.yd.	.50	.50	1.00
50. Construct control house, except conc.—total	500.00	300.00	500.00
51. Grouted paving—1,450 sq.yd.	1.50	4.00	3.00
52. Install trash rack metalwork—50,000 lb.	.02	.03	.03
53. Install slide gates, metal cond. linings—225,000 lb.	.04	.05	.02
54. Install gate controls—8,000 lb.	.10	.12	.10
55. Install outlet pipes—164,000 lb.	.02	.03	.02
56. Install metal stairs, walkways—22,000 lb.	.04	.05	.10
57. Install pipe handrails—6,000 lb.	.05	.06	.10
58. Install misc. metal work—54,000 lb.	.05	.10	.10
59. Install elec. metal conduit, to 1½ in.—650 lin.ft.	.20	.20	.20
60. Install elec. conductors, apparatus, etc.—total	500.00	300.00	500.00

Current Construction Unit Prices

Highway Bridges and Underpass, Maine

THREE reinforced concrete and structural steel bridges and one underpass are now being built under contracts awarded in August and September, 1936, by the Maine state highway commission. On three of the projects separate contracts were let for substructure and superstructure. The quantities, total bids and unit prices of the three low bidders on each of the seven contracts are given in the following tables. L. D. Barrows is chief engineer of the commission.

I — Morse Bridge, Androscoggin River, Rumford

(A)	Wyman & Simpson, Inc., Augusta, Me. (contract)	$73,836
(B)	Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.	89,592
(C)	Jos. P. McCabe, Inc., So. Boston, Mass.	95,513

II — Fairground Underpass, Lewiston

Substructure:

(D)	Wyman & Simpson, Inc., Augusta, Me. (contract)	87,595
(E)	Jos. P. McCabe, Inc., So. Boston, Mass.	89,603
(F)	Hector J. Cyr Co., Waterville, Me.	96,431

Superstructure:

(G)	Phoenix Bridge Co., Phoenixville, Pa. (contract)	39,362
(H)	American Bridge Co., Boston, Mass.	40,896
(J)	Bethlehem Steel Co., Bethlehem, Pa.	42,174

III — Saco River, Biddleford and Saco

Substructure:

(K)	J. H. Simonds Co., Portland, Me. (contract)	37,086
(L)	Jos. P. McCabe, Inc., So. Boston, Mass.	39,959
(M)	Simpson Bros. Corp., Boston, Mass.	41,556

Superstructure:

(N)	Harris Structural Steel Co., New York, N. Y. (contract)	31,537
(O)	Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.	32,160
(P)	Phoenix Bridge Co., Phoenixville, Pa.	32,817

IV — Bull's Eye Bridge, Kenduskeag River, Bangor

Substructure:

(R)	W. H. McPherson, Bangor, Me. (contract)	37,804
(S)	Hector J. Cyr Co., Waterville, Me.	44,238
(T)	Cyr Bros. Co., Waterville, Me.	44,285

Superstructure:

(U)	Boston Bridge Works, Cambridge, Mass. (contract)	21,042
(V)	American Bridge Co., Boston, Mass.	21,240
(W)	Bethlehem Steel Co., Bethlehem, Pa.	21,662

MAINE HIGHWAY BRIDGES

I — Morse Bridge, Androscoggin River

Item	A	B	C
1. Move superstructure—total	$25,000	$36,000	$45,000
2. Remove substructure, approaches—2,270 cu.yd.	3.00	2.50	3.00
3. Cofferdams—total	7,000	12,000	7,500
4. Excav. abutments, 6 ft.—200 cu.yd.	2.00	4.00	4.00
5. Excav. abutments, 6–18 ft.—120 cu.yd.	3.00	4.00	4.00
6. Excav. piers, 6 ft.—65 cu.yd.	2.00	5.00	4.00
7. Excav. piers, 6–18 ft.—130 cu.yd.	4.00	5.00	4.00
8. Excav. piers, 18 ft. plus—260 cu.yd.	5.00	8.00	4.00
9. Level ledge—35 sq. yd.	3.00	5.00	2.00
10. Rock excavation—25 cu.yd.	10.00	20.00	20.00
11. Concrete abutments—760 cu.yd.	10.50	13.00	15.00
12. Concrete piers—520 cu. yd.	11.30	13.00	15.00
13. Concrete sidewalks, roads—52 cu.yd.	18.00	20.00	15.00
14. Concrete wearing surface—15 cu.yd.	10.00	15.00	10.00
15. Concrete rail—99 lin.ft.	3.50	3.00	4.00
16. Concrete light posts—4, each	40.00	25.00	25.00
17. Elec. light conduit—72 lin.ft.	.40	.25	.50
18. Cement—1,780 bbl.	3.80	3.00	3.50
19. Reinforcing steel—15,500 lb.	.04	.03	.04
20. Place reinforcing steel—15,500 lb.	.01	.01	.01
21. Struct. steel—67,000 lb.	.08	.04	.035
22. Struct. steel placed—67,000 lb.	.025	.01	.005
23. Backfill—160 cu.yd.	1.50	1.50	1.00
24. Approach fill—450 cu.yd.	1.00	1.50	1.00
25. Riprap—250 cu.yd.	2.10	3.00	3.00
26. Gravel surfacing—350 cu.yd.	1.50	4.00	2.00
27. Concrete sidewalks—10 cu. yd.	15.00	20.00	12.00
28. Junction boxes—2, each	10.00	6.00	3.00

II — Fairground Underpass

Item — Substructure	D	E	F
1. Maintain traffic—total	$2,740	$1,200	$2,500
2. Excav. abutments, walls, roadways—19,500 cu.yd.	.48	.60	.70
3. General excavation—3,000 cu.yd.	1.00	2.70	2.00
4. Concrete cribbing—6.5 cu.yd.	60.00	42.00	45.00
5. Crib fill—32 cu.yd.	3.00	1.80	1.25
6. Concrete, abutments, retaining walls—2,755 cu.yd.	9.50	8.00	11.30
7. Concrete, culverts, cradles—40 cu.yd.	14.00	16.00	14.00
8. Concrete bridge deck—25 cu.yd.	20.00	14.00	20.00
9. Cement—5,100 bbl.	3.25	3.35	3.20
10. Reinforcing steel—45,000 lb.	.032	.04	.04
11. Place reinforcing steel—45,000 lb.	.007	.005	.015
12. Backfill—4,100 cu.yd.	.90	.60	.60
13. Riprap—75 cu.yd.	3.00	2.00	3.00
14. Gravel base—1,900 cu.yd.	1.40	.60	.70
15. Gravel surfacing—325 cu.yd.	1.60	1.20	1.50
16. Concrete, roadway, curbs—800 cu.yd.	6.00	8.00	7.00
17. Bituminous treatment—150 gal.	.30	.24	.40
18. Cobble stone cutter—190 sq.yd.	2.00	2.40	3.00
19. Gravel fill—200 cu.yd.	1.40	.60	1.00
20. Crushed stone fill—175 cu.yd	3.40	3.60	3.00
21. Drop inlets—5, each	65.00	54.00	100.00
22. Catch basins—3, each	90.00	90.00	125.00
23. Manholes—6, each	135.00	96.00	140.00
24. Cast iron grates—8, each	12.00	9.60	9.00
25. Manhole covers, collars—6, each	20.00	18.00	12.00
26. C.I. grates, 8 in. pipe—4, each	5.00	1.20	10.00
27. C.I. scuppers—10, each	20.00	6.00	6.00
28. Orn. iron fence—260 lin.ft.	2.00	4.80	4.00
29. Waterproof bridge deck—500 sq.yd.	5.50	5.00	1.00
30. Reinf. conc. pipe, 12 in.—14 lin.ft.	1.50	1.80	1.50
31. Reinf. conc. pipe, 15 in.—6 lin.ft.	2.00	2.40	2.00
32. Reinf. conc. pipe, 20 in.—5 lin.ft.	4.00	5.00	2.75
33. Reinf. conc. pipe, 24 in.—1,560 lin.ft.	2.90	3.30	3.00
34. C.I. pipe, 6 in.—46 lin. ft.	1.50	2.05	1.00
35. C.I. pipe, 8 in.—140 lin.ft.	1.70	2.50	1.50
36. Perf. asphalt, metal pipe, 4 in.—650 lin.ft.	.70	1.00	.70
37. Perf. asphalt, metal pipe, 6 in.—610 lin.ft.	.85	1.00	.80
38. Vitrif. clay pipe, 6 in.—10 lin.ft	.35	.30	.40
39. Vitrif. clay pipe, 8 in.—25 lin.ft	.45	.40	.65
40. Vitrif. clay pipe, 10 in.—440 lin.ft	.70	.60	.55
41. Vitrif. clay pipe, 12 in.—500 lin.ft.	.80	.70	.70
42. Vitrif. clay pipe, 20 in.—375 lin.ft.	2.50	2.40	2.00
43. Corr. metal asph. cov. pipe, 10 in.—50 lin.ft.	1.35	1.30	1.50
44. Relay 6 in. vitrif. clay pipe—30 lin.ft.	.50	.25	.40

Item — Superstructure	G	H	J
1. Struct. steel fabricated—852,000 lb.	$.0402	$.0408	$.0385
2. Struct. steel erection—852,000 lb.	.006	.0072	.011

III — Saco River

Item — Substructure	K	L	M
1. Remove existing struct.—total	$150.00	$260.00	$400.00
2. Remove substruct.—840 cu.yd.	1.50	2.00	2.50
3. Maintain traffic—total	2,500	2,000	2,500
4. Cofferdams—total	5,000	6,500	3,000
5. Excav. abutments to 6 ft.—110 cu.yd.	1.00	1.80	4.00
6. Excav. piers to 6 ft.—155 cu.yd.	1.50	3.50	6.00
7. Excav. abutments, 6–18 ft.—5 cu.yd.	10.00	1.80	8.00
8. Excav. piers, 6–18 ft.—60 cu.yd.	4.00	3.50	10.00
9. Level ledge—25 sq.yd.	3.00	1.80	4.00
10. Rock excav. piers—5 cu.yd.	12.00	5.00	10.00
11. Wood piles—2,325 lin.ft.	.60	.50	.60
12. Concrete abutments—150 cu.yd.	11.20	12.20	15.00
13. Concrete piers—580 cu.yd.	11.50	12.20	15.00
14. Concrete bridge slab—201 cu.yd.	11.75	12.20	15.00
15. Concrete wearing surface—100 cu.yd.	10.00	7.20	15.00
16. Concrete rail—285 lin.ft.	2.50	2.20	3.00
17. Cement—1,440 bbl.	3.03	3.20	3.50
18. Reinf. steel—59,780 lb.	.032	.035	.035
19. Place reinf. steel—59,780 lb.	.0075	.005	.01
20. Backfill—130 cu.yd.	.50	1.00	1.00
21. Approach fill—7,000 cu.yd.	.55	.65	.40
22. Stone fill—120 cu.yd.	1.50	2.00	3.00
23. Gravel base—1,300 cu.yd.	.80	.90	.80
24. Gravel surfacing—280 cu.yd.	1.70	1.50	1.50
25. Guard rail on approaches—1,780 lin.ft.	.45	.45	.45
26. Cable anchorages—4, each	20.00	16.00	15.00
27. Cable anchorages outside bridge—10, each	8.50	8.00	10.00
28. Cast iron drains—24, each	12.00	7.00	10.00

Item — Superstructure	N	O	P
1. Struct. steel fabricated—494,000 lb.	$.044	$.0425	$.0449
2. Struct. steel erection—494,000 lb.	.0165	.0202	.018
3. Bronze plates—166 lb.	.40	.50	.60
4. Bronze plates erected—166 lb.	.20	.05	.018
5. Steel rail—456 lin.ft.	2.60	1.80	3.25
6. Steel rail erected—456 lin.ft.	.80	.60	.35

IV — Kenduskeag River

Item — Substructure	R	S	T
1. Remove superstructure	$250.00	$800.00	$600.00
2. Remove substruct. and fill—800 cu.yd.	1.25	1.00	1.50
3. Maintain traffic—total	500.00	4,200	3,000
4. Cofferdams—total	1,000	3,200	2,500
5. Excav. abutments to 6 ft.—900 cu.yd.	1.00	1.75	2.50
6. Excav. abutments, 6–18 ft.—600 cu.yd.	2.50	1.75	2.50
7. Level ledge—80 sq.yd.	3.50	2.00	2.50
8. Rock excav. to 6 ft.—100 cu.yd	3.50	4.00	5.00
9. Wood piles—3,000 ft.	.70	.70	.75
10. Concrete abutment—1600 cu.yd.	9.00	10.50	10.25
11. Concrete roadway slab—100 cu.yd.	20.00	12.00	13.00
12. Concrete wearing surface—45 cu.yd.	15.00	9.00	10.00
13. Cement—2,300 bbl.	3.40	3.30	3.25
14. Reinf. steel—39,500 lb.	.04	.0325	.035
15. Place reinf. steel—39,500.	.02	.01	.01
16. Backfill—600 cu.yd.	1.00	.60	1.00
17. Approach fill—1,800 cu.yd.	.60	.50	.75
18. Riprap—120 cu.yd.	3.50	2.50	2.00
19. Gravel surfacing—220 cu.yd.	1.50	1.50	1.20
20. Guard rail—350 lin.ft.	.50	.45	.60
21. Anchorages, bridge—4, each	18.00	16.00	17.00
22. Anchorages, outside—4, each	15.00	10.00	15.00
23. Cast iron drains—16, each	12.00	8.00	5.00

Item — Superstructure	U	V	W
1. Struct. steel fabricated—340,000 lb.	$.0414	$.0424	$.043
2. Struct. steel erection—340,000 lb.	.0174	.0176	.0175
3. Rail, delivered—420 lin.ft	1.72	1.50	1.90
4. Rail erected—420 lin.ft.	.78	.50	.70